NATIVE FISH SOCIETY
Advancing the Recovery of Native, Wild Fish in Their Homewaters

May 1, 2015

NOAA Fisheries
Attn: Steve Leider
Email: steve.Leider@noaa.gov

Dear Mr. Leider:

We are writing in response to NOAA's recent announcement that it intends to abandon its 2004 commitment to conduct a thorough, watershed-scale scientific Environmental Impact Statement (EIS) of Puget Sound Hatchery Genetic Management Plans (HGMPs) and the potential impacts on threatened wild steelhead populations in favor of multiple, less rigorous Environmental Assessments (EAs).

Nave Fish Society (NFS) and our over 700 members from across the Pacific Northwest are deeply opposed to NOAA's proposal and would like to share the following comments:

(1) Puget Sound winter steelhead are listed as threatened and are protected under the Endangered Species Act (ESA). During the 2007 listing, NOAA cited, among other factors, steelhead hatchery programs as among the primary causes of the wild winter steelhead declines. Since then, considerable controversy and ample scientific data have further linked WDFW's hatchery management practices to declines in listed Puget Sound steelhead populations (Araki et al. 2007, 2008, 2009, 2010; Chilcote et al. 2011,2013; Christie et al. 2011,2014; Pflug et al. 2013). Under these circumstances, a thorough, scientifically rigorous and detailed EIS is required under NEPA to assess the potential impacts of Puget Sound HGMPs on listed steelhead.

(2) The EAs proposed by NOAA are not a replacement for an EIS. Compared to an EIS, EAs lack scientific and comprehensive rigor, often contain unverified assumptions, and offer an incomplete scientific evaluation of potential impacts. NEPA and ESA requirements are not satisfied by an evaluation process that does not assess full cumulative effects of Puget Sound hatchery steelhead programs. It is our concern that genetic risks of the hatchery programs in question will not have sufficient evaluation without a comprehensive scientific review and verifying the data that is relied upon to support conclusions.

As NEPA and ESA have served as the bedrock of modern environmental and species protection and recovery since their passage in 1970 and 1973 respectively, to allow an EA to replace an EIS in this situation would have widespread, prescient-setting consequences, not only for the recovery of listed steelhead in Puget Sound, but for other listed species across the United States.

(3) NOAA has defended its decision to abandon a Puget Sound-wide EIS by citing significant unspecified changes in hatchery programs since the co-managers jointly submitted their plans in 2004. NFS is not aware of any credible scientific evidence to support this assumption, and furthermore, we assert that the opposite has been observed throughout Puget Sound (Ford 2010; Berejikian and Ford 2004; Leider et al. 1990; Mobrand et al. 2005).

Because of the uncertainty, public concern, and controversy around this issue, NOAA needs to move forward with its original commitment to conduct a rigorous EIS to determine conclusively the impacts of Washington's HGMPs on listed wild steelhead and to inform future management decisions.

(4) In response to concerns over the legality of pursuing EAs over an EIS, NOAA has suggested that, because of joint tribal and state hatchery program management, NOAA has the flexibility to exercise its digression over the evaluation of Puget Sound HGMPs under ESA 4(d). ESA 4(d) was established prior to the 2004 commitment of NOAA and its co-mangers to pursue a DEIS and is therefore irrelevant to the discussion. Despite the existence of ESA 4(d), NOAA and its partners, including tribes, stated their intent in 2004 to conduct a DEIS. To now cite ESA 4(d) when all parties have previously agreed upon an EIS as the preferred course of action is unacceptable. We believe that ESA Section 4(d) is being used as to strategically and blatantly circumvent the science-based, transparent public process outlined by ESA and NEPA and designed to protect endangered species.

Because of concerns outlined above and the complexity and importance of this issue, Native Fish Society is requesting a full EIS evaluation of Puget Sound HGMPs. If our request for a full EIS evaluation is not granted immediately, due to the documented impacts of hatchery origin fish on Puget Sound steelhead, Native Fish Society and our partners demand a full 60 day extension of the original comment period and public hearing process to allow for full transparency and an in depth review of this critically important federal decision.

Respectfully submitted,

Erica Stock, Executive Director

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EWSteelheadHatcheries wcr - NOAA Service Account
<ewsteelheadhatcheries.wcr@noaa.gov>

Comments on Early Winter Steelhead Hatchery Programs

2 messages

Peter Soverel <soverel@wildsalmonrivers.org> Wed, Apr 15, 2015 at 7:27 PM
Reply-To: soverel@wildsalmonrivers.org
To: EWSteelheadHatcheries.wcr@noaa.gov

The Conservation Angler (TCA)provides the following comments regarding the NOAA decision to replace analysis of several Puget Sound winter steelhead hatchery programs in a detailed DEIS with a simple Environmental Analysis which, itself is not available for review.

TCA objects strenuously to this proposal which we view as an inappropriate, almost certainly illegal, slight of hand. This move is a blatant attempt to avoid addressing the many deficiencies (see below) raised in the public comment period on the DEIS review of the proposed WDFW Puget Sound winter steelhead hatchery program reviewed by the HGMP's in question.

I have been deeply engaged in salmon and steelhead conservation for over forty years and have, myself, directed international steelhead conservation & research projects in cooperation with foreign governments and scientific communities. I have never seen anything like this in all those years. It should be beneath the dignity, integrity and scientific credibility of NOAA to even consider this approach.

We note:

- NOAA itself required WDFW to provide HGMP's for these programs in 2001 that NOAA would review in detailed environmental review processes as required by NEPA;
- NOAA, notwithstanding over a decade of opportunity to conduct such NEPA review, did nothing;
- NOAA listed Puget Sound winter steelhead as threatened in 2007 citing, among other factors, steelhead hatchery programs as a primary cause for the declines of wild winter steelhead that forced the listing which is, of course, the rationale for detailed HGMP's and subsequent detailed analysis of the proposed hatchery operations in a federal EIS – risks, benefits, alternatives and so on;
- NOAA solicited public comments for the DEIS on the submitted HGMPs and received over 500 pages of detailed comments from tribes; prominent, science based NGO (such as Wild Fish Conservancy, Trout Unlimited, TCA and others) supported by extensive literature citations, accompanying graphs and analysis by prominent non-governmental scientists; and individuals. These agencies and groups invested, at federal invitation, immense resources to provide comments, analysis and recommendations which NOAA now proposes to simply discard and ignore;
- During this fourteen year period, WDFW has been operating their steelhead hatcheries illegally and without coverage under the Endangered Species Act.;
- Not withstanding NOAA's decade plus of inaction, they spring this proposal on the public without the actual document, the underlying, updated HGMP's and provide an inflexible 30 day comment period rejecting out of hand suggestions for an extension of the comment period.

This entire process is outrageous.

NOAA failed to act for more than a decade. They solicited public comment on the DEIS which my organization and many others submitted at considerable time and expense. Now imperially, NOAA proposes to scrape the DEIS and replace it with a simple EA. TCA, along with others, noted the many deficiencies of the DEIS itself – lack of standards, lack of regulatory authority, lack of funded monitoring to measure the actual impact of the proposed hatchery operations, lack of reasonable alternatives such is no hatcheries and so on. Without such detailed analysis, the impact of the hatchery programs on listed steelhead is just unknown and does not meet the requirements of the ESA or the public interest in careful husbanding of our natural resources.

The low bar of an EA requires the least amount of review possible under federal law and does not fulfill the requirements or purposes of NEPA (National Environmental Policy Act). Only through the process of completing

a full EIS can NOAA adequately evaluate the cumulative effects of all Puget Sound hatchery programs on threatened and endangered species including Puget Sound's wild steelhead.

Offering the public only 30 days to examine, analyze, and submit comments is unreasonable as the proposal to replace the draft EIS process with a much less rigorous EA transforms the issues dramatically and will not provide the sort of detailed analysis required to recover listed Puget Sound wild winter steelhead . We urge NOAA to withdraw the proposed EA and return to the process that itself demanded and initiated over a decade ago a full EIS starting with a DEIS.

Regards,
Peter Soverel
President, The Conservation Angler

Peter Soverel
[redacted]

EWSteelheadHatcheries wcr - NOAA Service Account Wed, Apr 15, 2015 at 7:27 PM
<ewsteelheadhatcheries.wcr@noaa.gov>
To: soverel@wildsalmonrivers.org

Thank you for commenting on the early winter steelhead hatcheries pending determination and draft environmental assessment. The comment period for this action will close at 5 p.m. Pacific time on April 27, 2015.

Steve Leider - NOAA Federal <steve.leider@noaa.gov>

RE: Update - Puget Sound Hatcheries draft EIS Withdrawal

1 message

Pete Soverel <soverel@wildsalmonrivers.org> Wed, Apr 15, 2015 at 7:34 PM
To: Steve Leider <steve.leider@noaa.gov>

Steve
I understand that NOAA has advised other organizations that requested an extension of the comment period that the request has been denied.

If that is the case, I ask that you apply our comment submitted earlier in the DEIS process be applied and addressed specifically in the EA.
Peter Soverel
The Conservation Angler

From: soverel@wildsalmonrivers.org
To: steve.leider@noaa.gov
Subject: RE: Update - Puget Sound Hatcheries draft EIS Withdrawal
Date: Sun, 12 Apr 2015 15:34:34 -0700

Steve
Please see the attached request for a 60 day extension of the comment period from The Conservation Angler.
Pete Soverel, President

From: steve.leider@noaa.gov
Date: Thu, 26 Mar 2015 14:59:31 -0700
Subject: Update - Puget Sound Hatcheries draft EIS Withdrawal
To:

You are receiving this message because of your interest in the Puget Sound hatcheries draft environmental impact statement (DEIS), which reviews over 100 Puget Sound hatchery salmon and steelhead programs under the National Environmental Policy Act. The DEIS was released in July of 2014, and the public comment period ended on January 23, 2015.

NOAA Fisheries is withdrawing the single Puget Sound-wide DEIS, as described below.

Because of the significant changes in hatchery programs since the co-managers jointly submitted their plans in 2004, and after considering public comments received on the DEIS, NOAA Fisheries is taking a new approach. Under this new approach, NOAA Fisheries is reviewing multiple hatchery programs as updated plans are jointly re-submitted to NOAA Fisheries by the co-managers. Some plans for hatchery programs have been re-submitted, and others are being revised for re-submission. In most cases, the plans are re-submitted at the watershed scale. Under this approach, NOAA Fisheries can review the effects of hatchery programs that are unique to each watershed and address the cumulative effects of hatchery programs. NOAA Fisheries has already begun reviews of re-submitted hatchery plans.

Environmental reviews of jointly re-submitted hatchery plans for steelhead are ongoing.

Information and analysis in the withdrawn DEIS and public comments received on it will be considered in future environmental reviews of watershed-specific hatchery programs.

For further information on the withdrawal of the draft EIS and what is replacing it, please see our NOAA Fisheries' West Coast Region website at: http://www.westcoast.fisheries.noaa.gov/hatcheries/ps_deis/ps_deis.html

If you have questions, please contact Steve Leider by email, Steve.Leider@noaa.gov, or by phone (360) 753-4650.

Steve Leider - NOAA Federal <steve.leider@noaa.gov>

Fwd: Wild Steelhead, HGMP, DEIS, etc

1 message

Tim Tynan - NOAA Federal <tim.tynan@noaa.gov> Wed, Apr 29, 2015 at 6:19 AM
To: Leider Steve <steve.leider@noaa.gov>

One non form letter comment, but same misunderstanding.

Sent from my iPhone

Begin forwarded message:

Not in mailbox 4/29/15 (3 pm)

From: <dcschaad@comcast.net>
Date: April 28, 2015 at 9:01:59 PM PDT
To: <ewsteeheadhatcheries.wcr@noaa.gov>, <tim.tynan@noaa.gov>, <robjones@noaa.gov>
Subject: Wild Steelhead, HGMP, DEIS, etc

Good Folk,

On behalf of the Washington Fly Fishing Club, I wish to express our extreme disappointment in the recent determination to forgo a complete EIS for resuming planting of Chambers Creek early winter steelhead in the Puget Sound basin.

Having previously provided testimony during the DEIS process, commenting on multiple HGMPs, and many years of serving as members on WDFW advisory groups, the recent decision to downgrade to an Environmental Analysis is entirely unacceptable. I may not have the dates quite right, but I'm sure we are now into the second decade of this issue. That is also unacceptable.

We sincerely hope that that production of Chambers Creek early winter steelhead will be discontinued, and funding for that activity is transferred to riparian restoration and removal of hydraulic barriers to wild steelhead spawning. Though the budgetary control within WDFW is beyond the jurisdiction of NMFS/NOAA, guidance from NMFS/NOAA can be instrumental in restoring wild steelhead (and other salmonids).

Respectfully submitted,

Douglas C Schaad

dcschaad@comcast.net

Co-Chair, Conservation Committee

Washington Fly Fishing Club

Executive Director

Whitewater Creek Conservation Association

May 4, 2015

Steve Leider
NMFS Sustainable Fisheries Division, West Coast Region
510 Desmond Drive SE, Suite 103
Lacey, WA 98503

Sent via email to: EWSteelheadHatcheries.wcr@noaa.gov

Re: Comments on Early Winter Steelhead Hatchery Programs

Dear Mr. Leider:

Trout Unlimited (TU), the nation's largest coldwater fisheries conservation organization dedicated to protecting and restoring our nation's trout and salmon resources and the watersheds that sustain them, submits this letter as comment on NOAA's National Marine Fisheries Service Environmental Assessment to Analyze Impacts of a NOAA's Proposed 4(d) Determination under Limit 6 for Three Early Winter Steelhead Programs in the Dungeness, Nooksack, and Stillaguamish River Basins, (hereafter referred to as the EA), and on NOAA's 4(d) Rule Under Limit 6 Proposed Evaluation and Pending Determination (hereafter referred to as Proposed Determination) regarding these programs.

At the outset TU wants to convey its strong disappointment with the public comment process for the EA and Proposed Determination. TU staff spent many days reading and commenting on a massive amount of material in NOAA's Draft Environmental Impact Statement and supporting Resource Management Plans and Hatchery Genetic Management Plans (HGMP) covering all of the salmon and steelhead hatcheries in Puget Sound, and submitted those comments in January 2015.[1] NOAA then decided (rightly) that that process was flawed and withdrew the EIS, as announced on March 26th. NOAA then published this EA and Proposed Determination addressing three early winter steelhead programs and provided just one month for public comment. The major process shift, the complexity of the issues that are the subject of the EA and Proposed Determination, and the fact that the EA and Proposed Determination, if approved and used as decision documents, would effectively approve long-term hatchery operations at these facilities, clearly warrant a longer time period in order for the public to provide constructive and detailed comments. Despite that fact, NOAA rejected TU's request for a 30-day extension of time to comment, and we are aware that several other stakeholders similarly requested an extension and were denied.

We are not going to belabor this point, but suffice it to say that NOAA's lack of willingness to provide for a reasonable period of time to review and comment on the EA and Proposed Determination hurts the agency's credibility with engaged stakeholders, like TU. We hope that NOAA will realize this as a problem and avoid similar missteps in the future. Below are our substantive comments on the two documents.

[1] TU's comments on the Puget Sound Hatchery EIS, dated January 23, 2015, focused heavily on steelhead and contain substantive comments that pertain to the EA as well. We incorporate those comments here by reference, and refer to them as "Puget Sound Hatchery DEIS Comments" in this comment letter.

1. <u>An Environmental Impact Statement is required to adequately analyze impacts and enable informed decision-making.</u>

An EIS is required for any action that is likely to have a significant effect on the quality of the human environment. 42 U.S.C. § 4332(2)(C). In determining whether likely effects are "significant," NEPA regulations require consideration of both the context and intensity of the proposed action. 40 C.F.R. § 1508.27. Among the factors to be considered in determining significance are: (1) the degree to which the effects are controversial; (2) whether the effects are uncertain; (3) whether the proposed action is precedential; (4) whether the proposed action would affect species protected under the Endangered Species Act (ESA); and (5) the extent to which the proposed action, when combined with other actions, could result in significant cumulative impacts. Moreover, a determination of "significance" cannot be avoided by breaking down a large set of related and interconnected actions into separate actions when, collectively, they are likely to have significant impacts.

The proposed action – using out-of-basin Chambers Creek early winter steelhead to provide harvest fisheries in river basins with ESA-listed steelhead and other ESA-listed salmonids -- is one that, upon considering the relevant factors, is clearly likely to have significant effects on the quality of the human environment, thus necessitating preparation of an EIS. In addition to affecting ESA-listed species, the Chambers Creek early winter steelhead hatchery programs are highly controversial, as evidenced by the lawsuit the Washington Department of Fish and Wildlife (WDFW) settled last year challenging the Chambers Creek hatchery program's compliance with the ESA. There is uncertainty around the full effects of Chambers Creek hatchery fish on listed wild steelhead populations (which is acknowledged in the Pending Determination), although new research that recently has come to light reveals that the threats to wild populations from segregated hatchery programs, such as the early winter steelhead programs in Puget Sound, are greater than previously thought. This point was addressed in TU's Puget Sound Hatchery EIS Comments, which are incorporated here by reference.

The proposed action is also precedential in that the underlying justification (providing steelhead for harvest) and analysis of the likely impacts of Chambers Creek early winter steelhead hatchery programs on wild steelhead generally would pertain to all of the early winter steelhead hatchery programs in Puget Sound. Accordingly, it is inappropriate to split that analysis up among individual EAs or EISs for specific hatcheries or groups of hatcheries. To ensure that the best scientific and commercial information is used to analyze the impacts, to ensure consistency, and to reduce the burden on the public to comment, the appropriate approach is to prepare an EIS covering all of the Puget Sound early winter steelhead programs that fully analyzes their likely impacts and then to tier individual EAs or EISs to that comprehensive EIS for specific hatcheries or groups of hatcheries. See 40 C.F.R. § 1508.28.

An EIS also is required because of the likely cumulative effects of all 19 early winter steelhead programs in Puget Sound. Among the cumulative effects that need to be considered comprehensively are: the effects of straying, density dependent effects in estuarine and marine environments, and effects on food web dynamics. Regarding density dependent effects, it bears emphasis that the Independent Scientific Advisory Board recently released a major report on this topic regarding the Columbia River Basin,

which pointed out the need to manage hatcheries in light of habitat capacity and density-related effects on wild fish.

2. <u>The effects analyses in the EA and the Pending Determination are inadequate to provide a basis for informed decision-making under NEPA and for determining compliance with the ESA.</u>

TU provided detailed comments on the Draft Puget Sound Hatchery EIS regarding shortcomings in the science and socio-economic analysis. We incorporate those comments by reference and offer additional comments below.

a. The EA does not accurately or fully account for continuing effects on wild steelhead from past management practices and inaccurately states that selection for early run timing effectively segregates spawning interactions between hatchery and wild steelhead.

The EA makes assumptions about the lack of interactions between wild steelhead and early-timed Chambers Creek steelhead that are inaccurate for several reasons. First, while the programs may have been initiated with the intent of reducing interactions with wild steelhead, there is overwhelming evidence that a substantial portion of wild steelhead historically entered rivers from late-November through January. Steelhead fishing seasons typically closed at the end of February in Washington State, and thousands of steelhead were caught annually in December and January, prior to the advent of Chambers Creek hatchery stock (Larson and Ward 1955; WDG 1956; Taylor 1979; McMillan 2008). In fact, estimates of steelhead catch in many of the streams were higher in December and January than they were in March (WDG 1956; Royal 1972; Taylor 1979). The historically earlier return timing would have provided substantial opportunities for wild steelhead to overlap and interact with Chambers Creek steelhead, not to mention there were high levels of harvest on wild steelhead as a result of fisheries focused on trying to maximize removal of wild steelhead.

Indeed, this is acknowledged at the end of the EA where a paper on historic population of steelhead in Puget Sound by Myers et al. (2014) suggests that the overall run timing has likely changed due to inadvertent harvest of early-returned wild steelhead, and NMFS indicated that genetic diversity for the native winter-run population may have been adversely affected by releases of non-native Chambers Creek steelhead from Kendall Creek Hatchery (Ford et al. 2011). This important reduction in run-timing and loss of genetic diversity is not quantitatively examined to determine the value of early-timed wild steelhead in recovering populations from the ESA. Hence, present assumptions in the EA about run-timing differences between hatchery and wild steelhead are being made after decades of harvest fisheries, and interbreeding and competition with Chambers Creek steelhead.

Second, despite alterations to historic population attributes (Myers et al. 2014), Seamons et al. (2004a, 2012) still found that using early-timed stock did not prevent interbreeding between wild and hatchery steelhead and that up to 80% of the offspring in a given year were from hatchery x wild matings. As a result, the authors (Seamons et al. 2012) concluded that "*Divergent life history failed to prevent interbreeding when physical isolation was ineffective, an inadequacy that is likely to prevail in many other situations."*

Recent observations in tributaries to the Skagit River also found substantial temporal overlap in spawn timing of hatchery Chambers Creek and wild steelhead (McMillan 2014), and findings of numerous redds (~120 redds) this year in Nookachamps Creek in the lower Skagit River revealed a large proportion of those redds were spawned prior to mid-March (WDFW's assumed deadline for the onset of spawning by wild steelhead, and the end of spawning by Chambers Creek steelhead), indicating there was potential for overlap between hatchery and wild steelhead. This means that although there has been strong selection against early-timed wild steelhead, the opportunities for interbreeding with Chambers Creek steelhead still appear to be greater than the ES assumes.

Third, the EA's evaluation of hatchery genetic effects (3.3.1., Pg. 27) relies heavily on introgression results by Warheit (2014), which found relatively low levels of introgression between Chambers Creek and wild steelhead in several Puget Sound streams. We arguet the Warheit study alone is not a sufficient basis for concluding that introgression is not a significant problem. As an example, NMFS staff raised several concerns about the estimates of introgression in the Warheit study because sample sizes, locations and life stages were not designed for the purpose of evaluating or testing population-scale introgression. Consequently, they stated that the study likely underestimates the true level of introgression (EA, Appendix A, Pg. 112).

In addition, the Warheit study was based primarily on adult sampling with some sampling at the smolt stage. Harmful introgression effects that may manifest at earlier life stages (egg, fry and parr) were not captured. Indeed, the research reveals that most hybrids do not survive to adulthood and introgression levels are often highest at the youngest life stages (Chilcote et al. 1986; Leider et al. 1990; Seamons et al. 2012). Thus, it is not surprising that samples of only adults and smolts would indicate low levels of gene flow between Chambers Creek hatchery stock and wild steelhead. While genetic introgression measurements at the adult and smolt stages are valuable metrics, they are not adequate to capture the cumulative level of actual introgression and its effects on the wild steelhead population.

Further, although mean levels of introgression were fairly low in Warheit (2014) at the population-scale, the mean and upper extent of 95% confidence intervals (CI) for Percent Effective Hatchery Contribution (PEHC) frequently exceeded the 2% threshold proposed by NMFS (EA: 3.3.1.- Genetic Risks, Pg. 29; Proposed Determination, Pg. 38) for individual groups of samples collected at specific times and locations (e.g., samples labeled NFSky1213 (mean = 3%, 95% CI up to 13%), NFToltAboveJuv11 (mean = 13%, 95% CI up to 26%), SFToltBelowJuv10 (mean=4%, 95% CI up to 14%), SnoqWindAd13 (mean=6%, 95% CI up to 27%), etc.). Moreover, it is compelling that the while mean PEHC was typically around 0% for the Nooksack population as a whole, the only sample that was designated as early returning adult winter steelhead from that population was also the only sample that exceeded the 2% threshold (EarlyAd sample: mean PECH 3% (95% CI = 0-10%) and the upper bounds of the 95% confidence intervals in all sample groups taken from the Nooksack except one exceeded the 2% threshold (some samples had upper 95% CI's of 10%). Despite these concerns, and while the approach in Warheit (2014) is reasonable given the relative paucity of data, we argue there is not enough data for the EA to assume that current levels of introgression are low enough to continue Chambers Creek programs in the Dungeness, Nooksack and Stillaguamish Rivers.

Fourth, while run-timing is partly under genetic control (Hendry et al. 2002) and hatchery managers have attempted to select for early-timed adults in Chambers Creek stock, steelhead and rainbow trout of different life histories commonly give rise to alternatives (Kendall et al. 2014). Additionally, spawn timing is also influenced by water temperature (Brannon et al. 2004) and relatively warmer or cooler thermal regimes could facilitate greater overlap between hatchery and wild steelhead. These factors could help explain why spawning hatchery and wild steelhead overlapped in Seamons et al. (2004, 2012) and McMillan (2014).

Fifth, a proportion of hatchery smolts never migrate to the ocean and instead remain in freshwater as residents or "residuals" (McMichael et al. 2000). Residency is more common in males than females (Rundio et al. 2012) and a variable proportion of those males will mature rather than become smolts (hereafter referred to as precocious males: Schmidt and House 1979; Tipping et al. 2003; Hausch and Melnychuk 2012). Precocious hatchery males are released into the river during or near the peak spawn time for wild steelhead and have been observed spawning with wild female steelhead (McMillan et al. 2007). Thus, selection for timing of return by adult steelhead does not eliminate precocial males with different spawn timing, indicating the potential spawn timing for Chambers Creek steelhead is broader than stated in the EA.

Precocious hatchery males could be a substantial problem in Puget Sound, yet the Proposed Determination (Pg. 38) states that they only represent a minimal vector for interbreeding with wild fish. We disagree per the following rationale. A recent review of residualism by Hausch and Melnychuk (2012) found that an average of 5.6% of smolts (for all sexes) residualized Range = 0-17%). Conservatively then, if only 2% of the males are precocious, the planned release of 10,000 smolts in the Dungeness River -- of which 5,000 are male -- would produce 100 precocious males. The release of 150,000 into the Nooksack River and 130,000 smolts into the Stillaguamish River would produce, 500 and 1,300 precocious males, respectively. This would compare to an average of only 244 wild male steelhead in the Dungeness (mean population size of 487 from 2011-2013) and 884 and 926 males in the Nooksack (mean population size of 1,768 males in Table 11, Pg. 37) and in the Stillaguamish Rivers (mean population size of 1,852 in Table 11, Pg. 37), respectively. The rivers also likely support wild resident rainbow trout and precocious parr (e.g., McMillan et al. 2007) that could offset the balance of hatchery males (e.g., Christie et al. 2011), but the numbers are not known. Regardless, precocious hatchery males are likely very common and may not only represent a genetic sink, but may also provide tremendous competition for wild male steelhead and trout. We could not find any citation or rationale for why NMFS would consider this potential level of interaction to be "minimal" (Proposed Determination, Pg. 38).

As a potential remedy, WDFW proposes that use of volitional release will reduce the number of residual steelhead, and presumably precocious parr (Proposed Determination, Pg. 50). However, a meta-review of residualism in hatchery steelhead found that volitional releases only reduced emigration of residuals by 4.6% compared to forced releases (Hausch and Melnychuk 2012), and smolts that are volitionally released may survive at lower rates (Gale et al. 2009), which is problematic from a production standpoint. Further, handling or sifting through tens-of-thousands of smolts is not a feasible approach to removing those that may be precocious. As a result, volitional release cannot uniformly assumed to be an effective strategy for substantially reducing the number of precocious parr entering rivers in late spring. We believe these factors need to be fully vetted in a quantitative manner. Hence, while we appreciate the

improved discussion of the potential problem of precocious parr (Appendix A, Pg. 108), we are disappointed that the EA and Proposed Determination to not take the next step to document the extent of precocious males and evaluate their effects on the wild populations of winter steelhead.

b. The Competition and Predation section does not fully include all relevant peer-reviewed information on the potential effects of hatchery steelhead smolts and residual parr on wild steelhead and other salmonids, such as Chinook salmon.

We agree with the finding in the EA that hatchery steelhead smolts and residual parr may pose significant ecological threats via competition and predation on wild steelhead and other salmonids. Although the Competition and Predation section (3.3.2., Pg. 29-31) addresses several important issues, it is not complete and, consequently, does not fully consider potential effects.

For example, Levin and Williams (2002) found that the survival from smolt to adult of natural-origin Chinook salmon in the Columbia River estuary from 1977-1994 was negatively related to numbers of hatchery steelhead smolts released. This paper is not cited, yet suggests the potential for the hatchery steelhead not only to influence steelhead smolt survival, but also survival of ESA-listed Chinook Salmon in Puget Sound. Similarly, Dawley et al. (1986) found in 1980-1983 that the mean daily stomach fullness of yearling Chinook salmon during peak period of outmigration in the Columbia River estuary was negatively correlated with abundance of smolts (including steelhead) and that diets of yearling Chinook and steelhead overlapped significantly. Thus, it is possible that there are significant density dependent effects being triggered or exacerbated by the release of numerous hatchery steelhead in Puget Sound. (As noted earlier in these comments, this is the type of cumulative effect necessitating preparation of an EIS.)

There is also the potential for a very high level of predation within freshwater by residual steelhead smolts. For example, Naman (2008) in a California stream found that a few thousand residual hatchery steelhead consumed over 24,000 salmon fry and 171,000 salmon eggs in just 21 days. Based on estimates of residualism of 0-17% (Hausch and Melnychuk 2012) it is plausible that there are at least a few thousand residual Chambers Creek steelhead smolts in the Nooksack and Stillaguamish Rivers, and that those fish may be consuming high levels of fry and salmon eggs. This is a particular concern for ESA-listed Chinook salmon.

c. The EA does not directly evaluate potential effects of Chambers Creek stock on phenotypic expression of life history diversity, such as run timing, and distribution of wild steelhead.

The expression of life histories and distribution allows steelhead and other species to adapt to short-term and long-term environmental variability (Moore et al. 2014). These critical aspects of the Viable Salmon Population concept (McElhany et al. 2000) must be

more fully addressed and evaluated before an informed decision can be made under NEPA and ESA compliance can be determined.

As previously discussed, there was a large early-timed component of wild steelhead in November, December and January in Puget Sound prior to the advent of the Chambers Creek hatchery stock (Larson and Ward 1955; Taylor 1979). And, there is currently more extensive overlap in spawn timing of Chambers Creek (e.g., Seamons et al. 2012) and wild steelhead than is acknowledged in the EA and Proposed Determination (e.g., McMillan 2008, 2014). Thus, interbreeding between Chambers Creek stock and wild steelhead, as well as the harvest of wild steelhead in fisheries targeting hatchery fish, has already strongly altered the run-timing of wild steelhead in Puget Sound (e.g., McMillan 2008), which is a critical aspect of life history diversity.

Additionally, interbreeding and competition with Chambers Creek steelhead has the potential to influence the spatial distribution of wild steelhead (e.g., Pearse et al. 2011) in locations where they spawn at similar times, which appears more common (e.g., Seamons et al. 2012; McMillan 2014) than the EA suggests. Consequently, it is erroneous to conclude, as the EA and Pending Determination do, that Chambers Creek steelhead have not and do not have the capacity to deleteriously influence life history diversity and distribution of wild steelhead. In fact, the overwhelming evidence suggests that deleterious effects are substantial and pervasive.

Changes to life history diversity and distribution have important implications for the future viability of wild steelhead in Puget Sound. Indeed, life history differences within and among steelhead represent the genetic and behavioral diversity that allows the species to adapt to short-term and long-term habitat changes over time (Moore et al. 2014). As an example, shifts in stream temperature and flow regimes related to climate change pose threats to wild steelhead (Waples et al. 2009), particularly in Puget Sound due to factors such as increased high flows during spawning and decreased summer low flows during rearing (Wade et al. 2009). Steelhead display remarkable plasticity and their life histories can change with a changing environment, but only if they have a reservoir of genetic and phenotypic diversity to draw upon (Moore et al. 2014; Kendall et al. 2014). Earlier spawning is likely to be part of the solution for wild steelhead persistence as it is now in warmer climates of coastal Oregon and northern California (Busby et al. 1996). It would provide juvenile fish the benefit of earlier emergence and greater growth entering summer, which will be critical to maintaining an evolutionary pace with the earlier onset and greater duration of summer low flows. This will not be possible however if the genetic and phenotypic diversity of steelhead continues to be limited and constrained by the early-timed Chambers Creek stock that currently occupy the early-timed niche in Puget Sound watersheds.

d. The evaluation of the socio-economic impacts of early winter steelhead hatchery programs with respect to sport and commercial harvest is deeply flawed and inaccurate.

The EA states that the early winter steelhead hatcheries in these three rivers provide substantial economic benefits generated through recreational angling (Section 3.6 Socioeconomics, Pg. 43-44). Specifically, the EA estimates that the annual economic value of these particular hatcheries is $1.89 million in angler expenditures and $3.58 million in economic output.

Put simply, these purported economic benefits are fiction and grossly inflated. They are based on multiple assumptions that are not grounded in reality. First, these benefit calculations are based on data set forth in Scott and Gill (2008), and those calculations appear to be based on all recreational steelhead fisheries in Puget Sound and the Strait of Juan De Fuca, not just harvest fisheries as stated in the EA. NOAA compounds this error by then erroneously assuming that all recreational angling expenditures and economic output is directly related to the level of hatchery production, ignoring the contribution of wild steelhead and catch-and-release fisheries to the recreational angling economy. NOAA then compounds the error again by assuming that the economic contribution of the hatcheries covered by the EA can be calculated using the percentage of steelhead smolts produced in Puget Sound by these particular facilities. Of course, the key statistic is not smolt production, but adult returns.

Far from providing a lot of angler opportunity, the fact is that early winter steelhead hatchery steelhead adult returns are typically very low providing little in the way of quality fishing opportunity in Puget Sound rivers (see Figure 1 attached). This is also true with respect to tribal fisheries. This raises the question of whether the small numbers of adults produced by the hatcheries addressed in the EA provide any economic benefits, particularly considering the risks they pose to wild steelhead and the recreational fishing closures they have likely contributed to. Again, we refer you to our comments on the Puget Sound Hatchery DEIS, which addressed problems with the socio-economic analysis that are also pertinent to this EA.

For all of the foregoing reasons, TU respectfully requests that NOAA prepare an EIS on the HGMPs covering the early winter steelhead hatcheries in the Dungeness, Nooksack and Stillaguamish basins. In addition, we ask that the agency refrain from making a 4(d) determination regarding the ESA consistency of the HGMPs for these hatcheries until it can make an informed decision based on the best available scientific and commercial information. Clearly, it is not able to do so at this juncture because of the major shortcomings in the current analysis set forth above.

In closing, TU wants to emphasize that our goal is to recover abundant, fishable populations of steelhead in Puget Sound, a goal that is broadly shared. We would submit, however, that the evidence clearly shows that continuation of Chambers Creek early winter steelhead programs is contrary to that goal. It is our desire to work with the co-managers and NOAA to develop a new approach that is much more likely to result in abundant, fishable steelhead populations, and we are open to all options that adequately protect wild steelhead populations and are based on sound science.

Thank you for your consideration.

Sincerely,

Rosendo Guerrero
Chair, Washington Council of Trout Unlimited

John McMillan
Science Director, Wild Steelhead Initiative

Cc: Will Stelle, Jr.
Barry Thom
Jim Scott, WDFW

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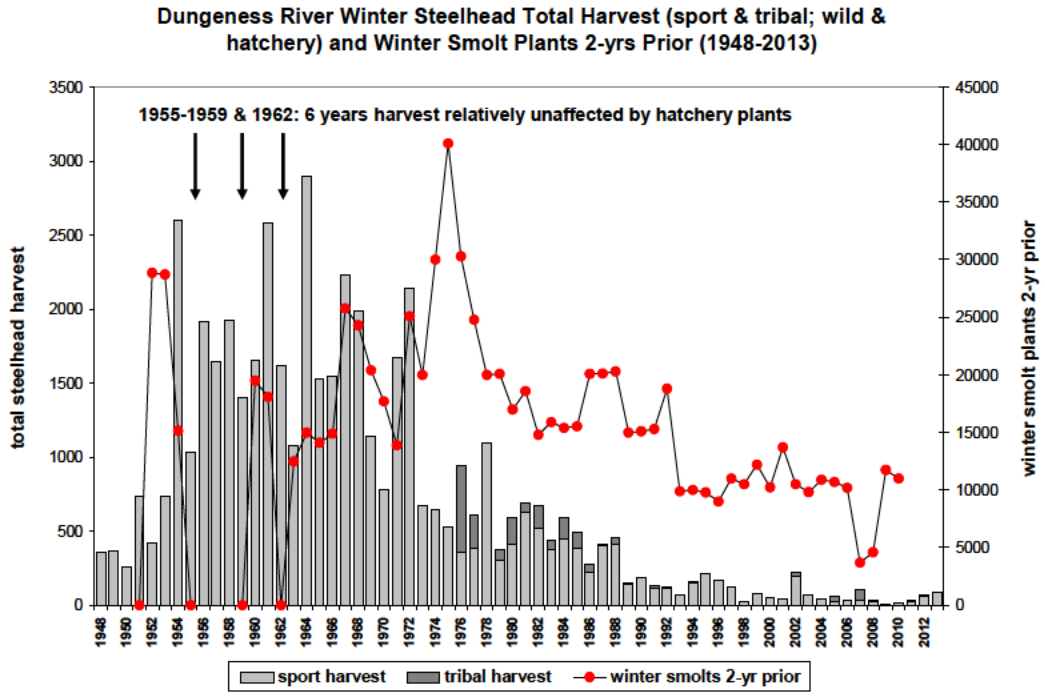
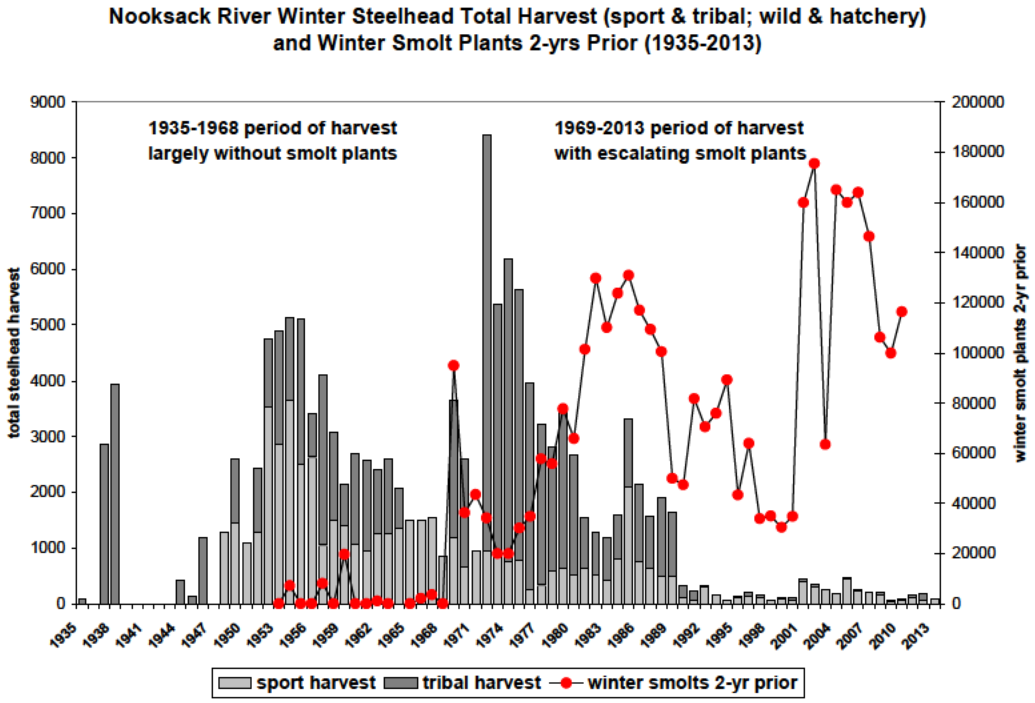
Figure 1. Number of hatchery winter steelhead smolts released and adult hatchery winter steelhead harvested for the a) Dungeness River, b) Nooksack River, and c) Stillaguamish River

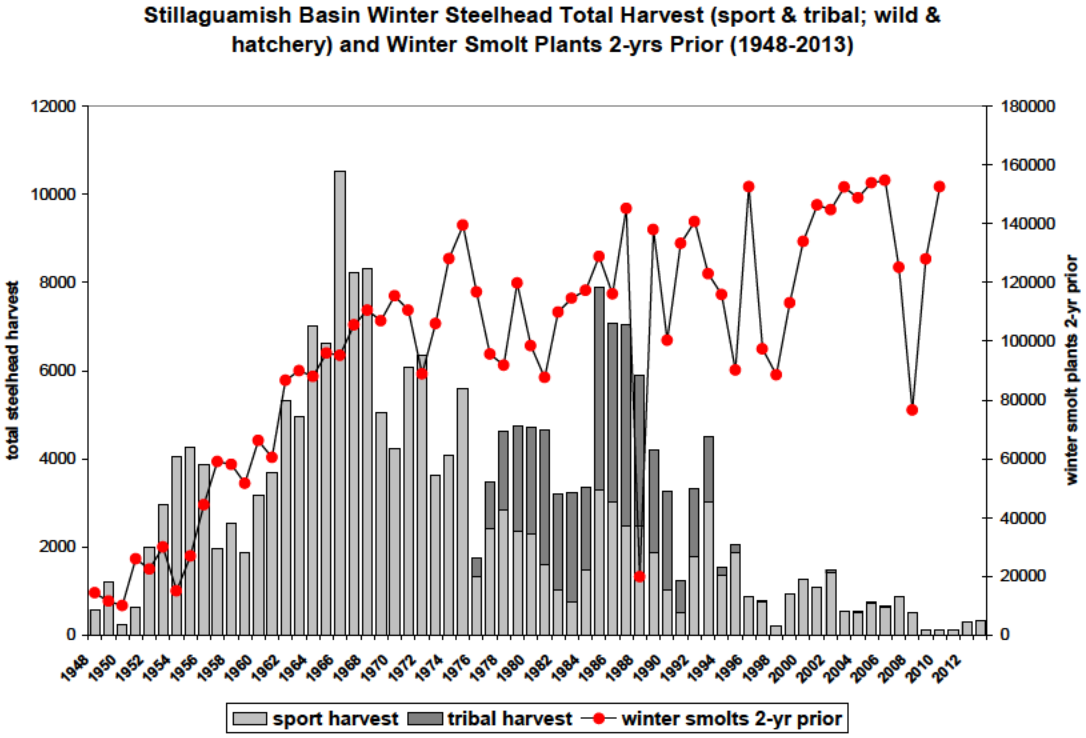
a.



b.



C.


Stillaguamish Basin Winter Steelhead Total Harvest (sport & tribal; wild & hatchery) and Winter Smolt Plants 2-yrs Prior (1948-2013)
total steelhead harvest
winter smolt plants 2-yr prior
0
2000
4000
6000
8000
10000
12000
0
20000
40000
60000
80000
100000
120000
140000
160000
180000
1948
1950
1952
1954
1956
1958
1960
1962
1964
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
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1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
sport harvest
tribal harvest
winter smolts 2-yr prior

Wild Fish Conservancy
NORTHWEST
SCIENCE EDUCATION ADVOCACY

May 4, 2015

Via Email
National Marine Fisheries Services
Sustainable Fisheries Division
510 Desmond Dr., Suite 103
Lacey, WA 98503
Email: EWSteelheadHatcheries.wcr@noaa.gov

Re: Environmental Assessment to Analyze Impacts of a NOAA's National Marine Fisheries Service Proposed 4(d) Determination under Limit 6 for Three Early Winter Steelhead Programs in the Dungeness, Nooksack, and Stillaguamish River Basins

Dear Honorable Civil Servants:

Please accept these comments submitted on behalf of the Wild Fish Conservancy, the Center for Biological Diversity, and the Wild Steelhead Coalition (collectively, "Commenters") on the Environmental Assessment to Analyze Impacts of a NOAA's National Marine Fisheries Service Proposed 4(d) Determination under Limit 6 for Three Early Winter Steelhead Programs in the Dungeness, Nooksack, and Stillaguamish River Basins (March 2015) ("Chambers Creek Draft EA").

Very truly yours,

Kurt Beardslee, Executive Director
Wild Fish Conservancy

I. **Introduction**.

The context in which the National Marine Fisheries Service's ("NMFS") Chambers Creek Draft EA has arisen is remarkable and deserves a brief discussion. It is beyond all reasonable dispute that the highly-domesticated Chambers Creek steelhead programs at issue adversely affect the Puget Sound steelhead distinct population segment ("DPS")—a threatened species under the Endangered Species Act ("ESA"). Puget Sound wild steelhead numbers are approximately 1 to 4% of their historical abundance. NMFS has identified Chambers Creek steelhead programs as one of the causes of the decline in wild Puget Sound steelhead. The current proposal to approve three of the six or seven such programs in Puget Sound with a cursory environmental assessment ("EA") and with minimal opportunity for public participation appears to be driven by political considerations without regard to the harm caused to threatened salmonids and the other costs of these hatchery programs.

NMFS listed the Puget Sound Chinook salmon evolutionary significant unit ("ESU") as a threatened species in 1999. 64 Fed. Reg. 14,308 (March 24, 1999). The State of Washington was required at that time to bring its hatcheries into compliance with the ESA. After failing to do so, Wild Fish Conservancy initiated litigation against the Washington Department of Fish and Wildlife ("WDFW") in 2002 alleging that the hatchery programs were harming protected fish in violation of the ESA. The parties settled that lawsuit with an agreement in 2003 under which WDFW committed to diligently pursue approval of its hatchery programs from NMFS under 50 C.F.R. § 223.203(b)—the "4(d) Rule."

WDFW, along with Puget Sound Treaty Tribes, submitted two joint resource management plans ("RMPs") and approximately 114 appended hatchery and genetic management plans ("HGMPs") for hatchery programs throughout Puget Sound in 2003 and 2004. NMFS announced its intent to prepare a full environmental impact statement ("EIS")

under the National Environmental Policy Act ("NEPA") rigorously evaluating the effects of and alternatives to these programs in 2004. 69 Fed. Reg. 26,364 (May 12, 2004).

The Puget Sound steelhead DPS then became a threatened species under the ESA in 2007. 72 Fed. Reg. 26,722 (May 11, 2007). Chambers Creek hatchery steelhead were excluded from the listed species because of the extent to which these hatchery fish have diverged from their wild counterparts through domestication in a hatchery environment. *See id.* at 26,722, 26,726. Moreover, NMFS identified these hatchery fish as a specific concern when it listed Puget Sound steelhead under the ESA:

> The [Biological Review Team ("BRT")] concluded that efforts by hatchery managers to prevent natural spawning by Chambers Creek winter-run…hatchery fish were unlikely to be completely effective, with potentially adverse consequences. The BRT concluded that opportunities for genetic and ecological interactions between hatchery and wild steelhead in Puget Sound were substantial, **with significant potential to reduce natural productivity.**

Id. at at 26,728 (emphasis added). Nonetheless, the Chambers Creek hatchery programs continued in Puget Sound without the EIS that NMFS had committed to complete and without any ESA authorization.

NMFS again expressed concern regarding Chambers Creek hatchery programs when it reviewed the status of Puget Sound steelhead in 2011, finding "increasing empirical evidence" demonstrating that "[g]enetically diverged and/or exogenous…Chambers Creek stocks pose threats to natural origin steelhead population viability." 5-Year Review: Summary & Evaluation of Puget Sound Chinook, Hood Canal Summer Chum, Puget Sound Steelhead, p. 29 (July 26, 2011). NMFS' status review further found that "[m]ost populations within the [Puget Sound steelhead] DPS are showing continued downward trends in estimated abundance, a few sharply so." The estimated mean population growth rates for all but a few populations within the Puget Sound steelhead DPS are declining—typically 3 to 10%

annually. Still, the Chambers Creek programs continued without any NEPA review or ESA authorization.

Shortly after the status review was issued, NMFS provided a second notice of its intent to prepare an EIS under NEPA rigorously evaluating the effects of and alternatives to the Puget Sound hatchery programs in 2011. 76 Fed. Reg. 45,515 (July 29, 2011).

Over ten years after settling the previous ESA lawsuit, Chambers Creek hatchery steelhead continued to be released into Puget Sound without the required ESA authorization and without the EIS that NMFS had committed to complete. With Puget Sound steelhead at critically low levels, Wild Fish Conservancy filed another citizen suit against WDFW under the ESA in early 2014, in an effort to prevent the unlawful releases of these hatchery fish. The parties settled that lawsuit through a Consent Decree entered by the Court on April 28, 2014. The Consent Decree prevented WDFW from releasing Chambers Creek hatchery fish into Puget Sound in 2014 from seven of its eight programs (releases were allowed in the Skykomish River). The Consent Decree will impose the same restrictions on this year's releases unless NMFS authorizes the hatchery programs under the ESA.

NMFS provided notice of the long-awaited draft EIS for its review and proposed approval of hatchery programs throughout Puget Sound on July 25, 2014 ("Puget Sound Hatchery DEIS"). NMFS extended the comment period on the Puget Sound Hatchery DEIS twice, providing approximately six months for public comment—through January 23, 2015. Numerous commenters, including Wild Fish Conservancy, expended significant resources providing detailed comments on the Puget Sound Hatchery DEIS. The Puget Sound Hatchery DEIS noted the significance of the process as the first NEPA analysis that would comprehensively address the effects of all hatchery programs operating within the geographic

boundaries of the ESA-listed species—the Puget Sound steelhead DPS and the Puget Sound Chinook salmon ESU.

Remarkably, after enormous efforts by all those involved, NMFS announced that it was withdrawing the Puget Sound Hatchery DEIS on March 26, 2015. 80 Fed. Reg. 15,986 (March 26, 2015). NMFS simultaneously announced its intent to approve the three Chambers Creek steelhead hatchery programs at issue here and the availability of the Chambers Creek Draft EA for a thirty-day public comment period. 80 Fed. Reg. 15,984 (March 26, 2015). After providing six months to comment on the Puget Sound Hatchery DEIS, NMFS has refused requests from several entities for a thirty-day extension of this comment period, indicating that WDFW has a "compelling need to complete the process…by May 22." Obviously WDFW wants to fast track the NEPA and ESA processes so that it can release Chambers Creek steelhead this spring. Further troubling is that it is apparent from the Tulalip Tribe's January 23, 2015, comment letter on the Puget Sound Hatchery DEIS that NMFS had already decided at that time to withdraw that NEPA document in lieu of new segmented evaluations, but it did not inform the public in a manner that could have saved significant resources.

These hatchery programs have operated without any ESA authorization since Puget Sound Chinook salmon were listed as threatened in 1999. NMFS should not now fast track and segment its NEPA and ESA processes due to political pressures. Rather, NMFS should complete a comprehensive EIS evaluating the costs and benefits of hatchery programs throughout Puget Sound before granting ESA authorization. Such an EIS is needed to fully inform decision-makers and the public of the true costs of these programs—both the economic costs and the burdens imposed on our environmental and ecological resources. At a very minimum, NMFS should review all of the Chambers Creek hatchery programs in a

single NEPA and ESA process to fully evaluate the effects these programs on the survival and recovery of the threatened Puget Sound steelhead DPS—especially given that WDFW submitted three other HGMPs for Chambers Creek steelhead hatchery programs simultaneously with those subject to the Chambers Creek Draft EA.

II. NMFS' Proposed Approval of the HGMPs under Limit 6 of the 4(d) Rule.

NMFS proposes to approve three HGMPs under Limit 6 of the 4(d) Rule. Such approval would exempt from liability "take" of threatened salmonids resulting from the hatchery operations described in the HGMPs. The HGMPs address Chambers Creek steelhead programs operating in three Puget Sound tributaries—the Nooksack River (Kendall Creek), the Stillaguamish River (Whitehorse Spring Creek), and the Dungeness River.

The HGMP for the Nooksack River programs proposes annual releases of 150,000 smolts. The Stillaguamish River HGMP proposes annual releases of 130,000 smolts. The Dungeness River program would release 10,000 smolts annually.

NMFS has described the development of the Chambers Creek steelhead stock as follows:

> The Chambers Creek winter-run steelhead stock was founded in the 1920s from the collection and spawning of native adult fish trapped in Chambers Creek, a south Puget Sound tributary. The propagation of Chambers Creek steelhead at this location occurred through 1945, when a new steelhead rearing program was initiated, leading to marked changes in this stock. In this new program, adult steelhead captured in Chambers Creek were transferred to the South Tacoma Hatchery in the upper watershed, where relatively warm water (12ºC) was available to accelerate spawning maturation time. Additionally, the earliest maturing fish were selected for propagation. Continuous year-to-year use of these practices, combined with the warmer water and nutritional advances provided by newly developed dry diets, allowed the production of smolts in one year instead of two. The first hatcheries outside the Chambers Creek watershed to use this stock were located on the Green and Puyallup rivers and on Tokul Creek. The progeny of adult returns established through transplants of Chambers Creek hatchery fish to these and other Puget Sound hatchery release sites were transferred back to Chambers Creek when needed to offset egg take shortfalls, and were incorporated back into the winter-run steelhead population maintained at the site. However, as a standard practice,

> Chambers Creek was maintained as the sole annual source of eggs for other hatcheries.
>
> Chambers Creek Hatchery, originally a private trout hatchery, was purchased by the Washington Department of Game in 1972 and rebuilt. This hatchery was subsequently used to propagate and further develop the Chambers Creek winter-run steelhead stock and became the major source of winter-run steelhead broodstock for western Washington. Chambers Creek-derived winter-run steelhead have been propagated and released from most Puget Sound steelhead facilities, including Reiter Ponds, Tokul Creek, Wallace River, Dungeness, Bogachiel, Hurd Creek, Eells Springs, Kendall Creek, McKinnon Ponds, Samish, Lake Whatcom, Puyallup, Soos Creek, Voights Creek, Marblemount, Barnaby Slough, Grandy Creek, Fabors Ferry, Baker River, Davis Slough, Whitehorse Ponds, Arlington, and the Chambers Creek facilities. Most of the programs using this transplanted stock are still active.
>
> The original goal of the Chambers Creek program was to produce an early returning adult steelhead that smolted after one year. By the mid 1970s, it was concluded that the advanced adult spawn timing selected to meet the yearling smolt objective created temporal separation in natural spawning areas between Chambers Creek hatchery winter-run and native late- winter-spawning steelhead, reducing the likelihood of interbreeding.

WDFW submitted several HGMPs for Chambers Creek steelhead programs simultaneously with those subject to the Chambers Creek Draft EA, each dated July 28, 2014. They covered programs operating in the following Puget Sound tributaries: the Duwamish/Green River (Soos Creek, Icy Creek, and Green River) (proposed annual releases of 70,000 smolts), the Snohomish River (Tokul Creek) (proposed annual releases of 74,000 smolts), and another in the Snohomish River (Wallace River, Reiter Ponds, and Skykomish River) (proposed annual releases of 256,000). It is entirely unclear how or why NMFS selected the three HGMPs addressed in the Chambers Creek Draft EA and not these other Chambers Creek HGMPs.

III. <u>NMFS' Proposed Approval will have Significant Impacts Requiring an EIS</u>.

NMFS' proposed decision to approve three programs that will release 290,000 Chambers Creek hatchery steelhead into Puget Sound rivers annually will have a significant impact on the environment. Accordingly, NEPA requires preparation of an EIS.

The purpose of NEPA is, *inter alia*, to declare a national policy that will encourage productive and enjoyable harmony between man and his environment, to promote efforts which will prevent or eliminate damage to the environment and biosphere and stimulate the health and welfare of man, and to enrich the understanding of the ecological systems and natural resources important to the Nation. 42 U.S.C. § 4321. NEPA requires federal agencies undertake processes to "insure that environmental information is available to public officials and citizens before decisions are made and before actions are taken" and that are "intended to help public officials make decisions that are based on understanding of environmental consequences." 40 C.F.R. §§ 1500.1(b) and (c).

To accomplish these purposes, NEPA requires federal agencies to prepare a "detailed statement" regarding all "major Federal actions significantly affecting the quality of the human environment." 42 U.S.C. § 4332(2)(C). The "detailed statement," commonly known as an EIS, is to describe the environmental impact of the proposed action, any adverse environmental effects which cannot be avoided should the proposal be implemented, alternatives to the proposed action, the relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity, and any irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented. The requirement to prepare an EIS serves two important purposes: 1) it ensures the agency, in reaching its decision, will have available, and will carefully consider, detailed information concerning significant environmental impacts, and 2) it guarantees that the relevant information will be made available to the larger audience that may also play a role in both the decision making process and the implementation of that decision. *Robertson v. Methow Valley Citizens Council*, 490 U.S. 332, 349 (1989).

Before preparing an EIS, an agency may prepare an EA if it is uncertain whether a proposed action may have a significant effect on the environment. 40 C.F.R. § 1508.9. The purpose of an EA is to provide the agency with sufficient evidence and analysis for determining whether to prepare an EIS or to issue a finding of no significant impact ("FONSI"). *Metcalf v. Daley*, 214 F.3d 1135, 1143 (9th Cir. 2000) (citing 40 C.F.R. § 1508.9). Given this limited purpose, an EA cannot substitute for an EIS where there may be a significant effect on the environment from a proposal:

> No matter how thorough, an EA can never substitute for preparation of an EIS… An EA simply assesses whether there will be a significant impact on the environment. An EIS weighs any significant impacts of the proposed action against the positive objectives of the project. Preparation of an EIS thus ensures that decision-makers know that there *is* a risk of significant environmental impact and take that impact into consideration. As such, an EIS is more likely to attract the time and attention of both policymakers and the public

Anderson v. Evans, 371 F.3d 475, 494 (9th Cir. 2002).

An EIS is required if a proposed action *may* have a significant effect on the environment. *Nat'l Parks & Conservation Ass'n*, 241 F.3d at 730; *Ocean Advocates v. U.S. Army Corps of Eng'rs*, 402 F.3d 846, 864-865 (9th Cir. 2005) ("if substantial questions are raised as to whether a project . . . *may* cause significant degradation…" (internal quotations omitted)). "This is a low standard." *Klamath SiskiyouWildlands Ctr.*, 468 F.3d at 562.

"Significantly" is defined to require an analysis of both the "context" and "intensity" of effects. 40 C.F.R. § 1508.27. The context of the action includes "society as a whole (human, national), the affected region, the affected interests, and the locality," as well as short- and long-term effects. *Id*. § 1508.27(a). There are ten non-exclusive intensity factors to be considered in the significance determination:

> (1) Impacts that may be both beneficial and adverse. A significant effect may exist even if the Federal agency believes that on balance the effect will be beneficial.

> (2) The degree to which the proposed action affects public health or safety.
>
> (3) Unique characteristics of the geographic area such as proximity to historic or cultural resources, park lands, prime farmlands, wetlands, wild and scenic rivers, or ecologically critical areas.
>
> (4) The degree to which the effects on the quality of the human environment are likely to be highly controversial.
>
> (5) The degree to which the possible effects on the human environment are highly uncertain or involve unique or unknown risks.
>
> (6) The degree to which the action may establish a precedent for future actions with significant effects or represents a decision in principle about a future consideration.
>
> (7) Whether the action is related to other actions with cumulatively significant impacts. Significance exists if it is reasonable to anticipate a cumulatively significant impact on the environment. Significance cannot be avoided by terming an action temporary or by breaking it down into small component parts.
>
> (8) The degree to which the action may adversely affect districts, sites, highways, structures, or objects listed in or eligible for listing in the National Register of Historic Places or may cause loss or destruction of significant scientific, cultural, or historical resources.
>
> (9) The degree to which the action may adversely affect an endangered or threatened species or its habitat that has been determined to be critical under the Endangered Species Act of 1973.
>
> (10) Whether the action threatens a violation of Federal, State, or local law or requirements imposed for the protection of the environment.

Id. § 1508.27(b). The potential presence of even one of these factors is sufficient to require an EIS. *See Ocean Advocates,*402 F.3d at 865; *and see Ctr. for Biological Diversity v. Nat'l Hwy. Traffic Safety Admin.*, 538 F.3d 1172, 1220 (9th Cir. 2008).

A. <u>The Context of NMFS' Proposed Approval Extraordinary</u>.

The location, multitude of affected interests, and broad temporal and spatial impacts magnify the significance of NMFS' proposed action. The Puget Sound region, including the Nooksack River, Stillaguamish River, and the Dungeness River support a diversity of cultures

and wildlife. There is immense scientific, cultural, and recreational interest in restoration of historic salmon runs, as well as immense taxpayer investment in restoration projects. The basin provides habitat for numerous species of concern, including several listed as threatened or endangered under the ESA. The intensity factors must be considered in light of this context. *See* 40 C.F.R. § 1508.27.

B. NMFS' Approval will have Significant Effects on Unique Characteristics of the Geographic Area.

The intensity analysis requires a consideration of effects to "[u]nique characteristics of the geographic area such as proximity to…park lands, … or ecologically critical areas." 40 C.F.R. § 1508.27(b)(3). NMFS' approval will have a significant effect on such areas that requires an EIS. For example, the hatchery programs will produce domesticated hatchery fish that will rear, migrate, and spawn in various protected public lands and in designated critical habitat for Puget Sound Chinook salmon. Moreover, the programs will produce hatchery fish in watersheds located partially in designated Wilderness Areas. Such areas are supposed to be "untrammeled by man, where man himself is a visitor who does not remain…, an area…retaining its primeval character and influence…, [and] which is protected and managed so as to preserve its natural conditions..." 16 U.S.C. § 1131(c).

C. The Actions may Establish a Precedent.

The "degree to which the action may establish a precedent for future actions with significant effects" warrants an EIS. *See* 40 C.F.R. § 1508.27(b)(6).

NMFS' proposed approval may establish a precedent for future actions with significant effects such that an EIS is required. Notably, there are over 100 HGMPs currently before NMFS for hatcheries operating throughout Puget Sound. The only other Puget Sound HGMPs that have been approved are those for the Elwha River—which were similarly hastily approved outside of an EIS process due to litigation challenging longstanding ESA violations.

NMFS cited to Elwha River approval as support for its withdrawal of the Puget Sound Hatchery EIS in lieu of its proposed segmented NEPA process. This indicates that NMFS already "feel[s] bound to the conclusions reached in [that] FONSI[]." *See Friends of the Earth v. U.S. Army Corps of Eng'rs*, 109 F. Supp. 2d 30, 43 (D.D.C. 2000); *and* Dkt. 164, 32:23-33:2. NMFS' reliance on the Elwha River process indicates that its proposed approval here will add to a "chain of bureaucratic commitment that will be progressively harder to undo the longer it continues." *Presidio Golf Club v. Nat'l Park Serv.*, 155 F.3d 1153, 1162-63 (9th Cir. 1998) (internal quotations omitted).

Further, there are currently several HGMPs for other Chambers Creek steelhead programs operating in Puget Sound before NMFS seeking approval under the 4(d) Rule. While the three HGMPs addressed in the Chambers Creek Draft EA propose annual releases of 290,000 smolts, the three additional HGMPS before NMFS propose annual releases of another 400,000 Chambers Creek smolts into Puget Sound. NMFS' proposed approval may set a precedent for its future action on these HGMPs.

The decision to treat the three HGMPs as a single RMP and the attendant decision to approve them by issuing a hastily drafted EA, instead of completing the comprehensive EIS on all Puget Sound hatcheries, in order to fast-track approval in hope that hatchery smolts can be released in early May 2015 sets a dangerous precedent of weakening the substantive public and environmental benefits of NEPA. Among other concerns, approval of this action by NMFS threatens to open the door to the approval of numerous individual HGMPs that can be bundled in small packages labeled as resource management plans. This would lead to widespread approval of numerous hatchery programs that impose significant risks to ESA-listed wild salmon and steelhead populations throughout the Pacific Northwest without having to subject them to a comprehensive NEPA evaluation and would deprive the public of its

ability to evaluate the full cumulative impacts of such approvals. This would also extend beyond salmon listed under the ESA and would encourage other environmental evaluations to avoid proper public review and proper comprehensive evaluation of adverse effects by considering one or several small actions in a piecemeal fashion. This would further undermine the purposes of NEPA.

D. <u>The Effects of the Actions are Uncertain</u>.

The extent to which the effects of an action are highly uncertain or involve unique or unknown risks must be considered in determining whether to prepare an EIS. 40 C.F.R. § 1508.27(5). An EIS is required because the harm posed by the hatcheries and the effectiveness of any mitigation efforts are highly uncertain.

For example, the hatchery programs will cause reduced reproductive fitness in the wild populations. The Chambers Creek Draft EA provides only a cursory description of potential genetic effects and concludes that genetic risks are low. As demonstrated throughout this letter and in the attached materials, including the declarations of Dr. Jack Stanford and Dr. Gordon Luikart, there is a significant disagreement on these issues. Section IV.F of these comments describe various uncertainties with the methods used by NMFS to evaluate genetic risks. Similar uncertainties exists with respect to other harmful effects, including those from ecological interactions, disease transmission, and facility effects.

Compounding these issues are the uncertainties regarding mitigation measures. NMFS' proposed approval of the HGMPs relies extensively on a belief that there will be effective monitoring and adaptive management that will avoid excessive adverse effects to wild salmonids. Such monitoring and adaptive management is only vaguely described. Moreover, whether and how such mitigation measures will be funded and implemented is uncertain. The current budget crisis in Washington State further threatens the budget of

WDFW and the funding the agency can devote to essential monitoring of these three programs.

Where, as here, there is "no evidence that the mitigation measures will significantly combat the mostly 'unknown' or inadequately known effects" of an action, "speculative and conclusory statements" are insufficient to demonstrate an EIS is not warranted. *See Nat'l Parks & Conservation Ass'n v. Babbitt*, 241 F.3d 722, 735 (9th Cir. 2001), *abrogated on other grounds*, 130 S.Ct. 2743 (2010).

E. <u>The Effects of the Actions are Controversial</u>.

An EIS is required if the effects of the action are controversial—if there is "'a substantial dispute [about] the size, nature, or effect" of the action. *See Blue Mountains*, 161 F.3d at 1212; *and* 40 C.F.R. §1508.27(b)(4). Where "conservationists, biologists, and other knowledgeable individuals" are "highly critical of the EA" and dispute the EA's conclusions regarding the effects of the proposed action, an EIS must follow. *Found. for N. Am. Wild Sheep v. U.S. Dep't of Agric.*, 681 F.2d 1172, 1182 (9th Cir. 1982); *and see Sierra Club v. U.S. Forest Serv.*, 843 F.2d 1190, 1193-94 (9th Cir. 1988). The effects of the actions are highly controversial, as demonstrated throughout these comments and attached materials, including the declarations of Dr. Jack Stanford and Dr. Gordon Luikart and the Statement of Scientists Regarding Risks Posed by Chambers Creek Hatchery Steelhead Programs to the Recovery of Wild Puget Sound Steelhead. For example, while the Chambers Creek Draft EA finds genetic risks from the programs low, Dr. Gordon Luikart—named by Thomas Reuters in 2014 as one of the World's Most Influential Minds for his genetic research—finds the genetic risks to be substantial. Further, Dr. Luikart considers the genetic risk from introgression levels (pHOS) deemed acceptable by NMFS to "likely pose significant harm to the fitness of

wild steelhead populations." Similar controversies exists with respect to other effects, such those from ecological interactions demonstrated by the Declaration of Dr. Jack Stanford.

F. <u>There are Significant Adverse Impacts on Protected Species</u>.

The degree to which an action *may* adversely affect ESA-listed species or their critical habitat must be considered in determining whether to prepare an EIS. 40 C.F.R. §1508.27(b)(9). The actions have significant adverse effects on threatened salmonids and their critical habitat warranting an EIS as briefly described below and as further described throughout this letter and the attached materials, including declarations of Dr. Jack Stanford and Dr. Gordon Luikart, submitted herewith.

As previously noted, NMFS identified Chambers Creek steelhead hatchery fish as a specific concern when it listed Puget Sound steelhead under the ESA:

> The [Biological Review Team ("BRT")] concluded that efforts by hatchery managers to prevent natural spawning by Chambers Creek winter-run…hatchery fish were unlikely to be completely effective, with potentially adverse consequences. The BRT concluded that opportunities for genetic and ecological interactions between hatchery and wild steelhead in Puget Sound were substantial, **with significant potential to reduce natural productivity.**

72 Fed. Reg. 26,728 (May 11, 2007). NMFS again expressed concern regarding Chambers Creek hatchery programs in its 2011 status review of the Puget Sound steelhead DPS, finding "increasing empirical evidence" demonstrating that "[g]enetically diverged and/or exogenous…Chambers Creek stocks pose threats to natural origin steelhead population viability." 5-Year Review: Summary & Evaluation of Puget Sound Chinook, Hood Canal Summer Chum, Puget Sound Steelhead, p. 29 (July 26, 2011).

That status review found that Puget Sound steelhead are at critically low levels—that "[m]ost populations within the [Puget Sound steelhead] DPS are showing continued downward trends in estimated abundance, a few sharply so." The estimated mean population

growth rates for all but a few populations within the Puget Sound steelhead DPS are declining—typically 3 to 10% annually.

As described in the declarations of Dr. Jack Stanford and Dr. Gordon Luikart submitted herewith, the hatchery programs will harm, delay, and even prevent, full recovery of Puget Sound steelhead.

The actions further adversely affect Puget Sound Chinook salmon critical habitat. Critical habitat for this species includes the watershed and adjacent marine waters of all three rivers, and primary constituent elements considered essential for such habitat include freshwater rearing sites free from excessive predation. The actions will reduce space for rearing and cause predation of wild salmonids.

An EIS is required because, *at a minimum*, there are substantial questions regarding whether there will be a significant impact on the environment given the known adverse effects to threatened salmonids, the uncertainties regarding the magnitude and duration of those effects, and the uncertainties regarding adaptive management necessary to mitigate such effects. *See Cascadia Wildlands v. U.S. Forest Serv.*, No. 6:12-CV-00804-AA, 2013 U.S. Dist. LEXIS 43759, at *32 (D. Or. Mar. 21, 2013).

G. <u>There are Cumulatively Significant Impacts</u>.

Agencies must consider whether an action is related to other actions with cumulatively significant impacts. 40 C.F.R. § 1508.27(b)(7). Significance exists, requiring an EIS, "if it is reasonable to anticipate a cumulatively significant impact on the environment," and an agency cannot avoid preparation of the EIS by "breaking it down into small component parts." *Id.* A cumulative impact "results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions . . . ." *Id.* at § 1508.7.

The three Chambers Creek hatchery programs addressed in the Chambers Creek Draft EA are related to the approximately one hundred other hatchery programs operating throughout Puget Sound. NMFS received HGMPs for these all these programs in 2003 and 2004 as part of two RMPs for review under the 4(d) Rule.

The programs cumulatively have significant impacts, including those on the continued survival and recovery of the threatened Puget Sound Chinook salmon ESU and the Puget Sound steelhead DPS. When asked why the Elwha River HGMPs are being evaluated in the programmatic EIS along with all of the other Puget Sound HGMPs, Tim Tynan testified under oath on behalf of NMFS as follows:

> Because collectively the Puget Sound programs in total have cumulative effects on listed fish populations, especially in marine areas. The suite of hatchery programs leads to the production of millions of salmon. And for us to have an accurate evaluation, we have to include all programs.

Deposition Transcript of Tim Tynan, p. 134, lns. 3-7. The Hatchery Scientific Review Group ("HSRG") similarly noted:

> Hatchery fish released in each subbasin will interact with wild and hatchery fish from other subbasins as they migrate through the downstream corridor, estuary and ocean. The effects of these interactions are heightened as the cumulative number of hatchery fish released into the Puget Sound for harvest increases. Therefore….the cumulative natural and hatchery production should take into account the carrying capacity of the migratory corridor, estuary and ocean.

A single EIS is required because, at a minimum, there are "substantial questions as to whether [NMFS' approval of the Puget Sound HGMPs] will have significant cumulative environmental effects." *See Thomas v. Peterson*, 753 F.2d 754, 759 (9th Cir. 1985). NMFS violated NEPA by segmenting out the three programs addressed in the Chambers Creek Draft EA.

The three programs addressed in the Chambers Creek Draft EA are, at a minimum, related to the other Chambers Creek hatchery programs operating in Puget Sound. As noted,

WDFW submitted six updated HGMPs for its Chambers Creek hatchery programs in Puget Sound on July 28, 2014—shortly after it settled the lawsuit with Wild Fish Conservancy concerning these programs. The Chambers Creek Draft EA addresses three of these programs that propose to release 290,000 smolts annually into Puget Sound tributaries. Not covered are three other HGMPs submitted to NMFS that propose to release another 400,000 smolts annually. NMFS' pending review and approval of WDFW's Chambers Creek programs operating in Puget Sound are related actions that have cumulatively significant effects that require consideration in an EIS. NMFS violated NEPA by segmenting out the three programs addressed in the Chambers Creek Draft EA.

NMFS' review of the other hatchery programs—those producing different fish stocks—at the same facilities addressed in the Chambers Creek Draft EA are related actions with cumulatively significant effect that require consideration in an EIS. NMFS violated NEPA by segmenting out the three programs addressed in the Chambers Creek Draft EA. Notably, by segmenting other programs out of its analyses, NMFS artificially masks the effects of its decision by assuming that various facility effects—such as those from improperly screened structures—will occur regardless of its action.

IV. <u>The Chambers Creek Draft EA Does Not Comply with NEPA</u>.

The Chambers Creek Draft EA does not satisfy the intent or requirements of NEPA because it fails to take a hard look at the effects of the proposed hatchery programs—which present an abundance of known and likely significant adverse effects on the environment, and in particular, on threatened fish species—and alternatives thereto. In addition to the deficiencies described below, the inadequacies of the Chambers Creek Draft EA are described throughout these comments—including those regarding the failure of the HGMPs to comply with the 4(d) Rule standards—and by the other materials submitted herewith.

A. **<u>The Description of the Purpose and Need is Inadequate</u>.**

The purpose and need statement is a crucial part of crafting and evaluating a reasonable range of alternatives because only a sufficiently broad statement will allow full development of an adequate range of alternatives. *See, e.g., Simmons v. U.S. Army Corps*, 120 F.3d 664 (7th Cir. 1997); *Davis v. Mineta*, 302 F.3d 1104, 1118 (10th Cir. 2002). Agencies cannot unnecessarily limit or interpret their purpose and thereby place unnecessary limits on the range of alternatives. *Id.*; *see also Van Abbema v. Fornell*, 807 F.2d 633, 638 (7th Cir. 1986), *see also 'Ilio'ulaokalani Coalition v. Rumsfeld*, 464 F.3d 1083 (9th Cir. 2006).

NMFS' description of the purpose and need is too vague to conduct any meaningful analysis of the alternatives. NMFS describes its purpose of the action as to:

- Ensure the proposed hatchery programs comply with requirements of the ESA;
- Meet NMFS's tribal treaty rights trust and fiduciary responsibilities; and
- Work collaboratively with WDFW and tribal co-managers to protect and conserve listed species.

WDFW and the Tribal co-managers' purpose and need for the Proposed Action is two-fold:

- Comply with requirements of the ESA; and
- Continue operation of on-going hatchery programs to provide tribal and recreational harvest opportunity for steelhead in the Dungeness, Nooksack, and Stillaguamish River Basins (Chambers Creek Draft EA, pp. 5-6).

However, NMFS does not provide any quantitative description of what is necessary to achieve these objectives. This stems, in part, from the absence of an approved recovery plan for Puget Sound steelhead and the failure to complete the Puget Sound Hatchery DEIS with

an attendant comprehensive cumulative effects analysis. NMFS' failure to adequately define the purpose and need of the programs prevents any meaningful evaluation of the alternatives.

In the recently withdrawn Puget Sound Hatchery DEIS, NMFS stated that "as a matter of policy, [NMFS] will accept some impacts that may result in increased risk to the listed species to provide limited tribal fishing opportunity. This approach recognizes that the treaty tribes have a right to conduct their fisheries within the limits of conservation constraints." *Puget Sound Hatchery DEIS.* at p. 1-9. Yet, neither in that document nor in the Chambers Creek Draft EA does NMFS provide any quantitative criteria related to risk to the ESA-listed species at issue nor any description of quantitative criteria by which NMFS determines how tribal fisheries contribute to such "increased risk," nor how that incremental level of risk is determined and how it is further determined that the incremental risk falls within the "conservation constraints." Similarly, the Chambers Creek Draft EA provides no description, quantitative or otherwise, of what level of "fishing opportunities" are necessary or appropriate. The failure to provide such criteria is inevitable, given NMFS' refusal to develop and apply a proper, comprehensive cumulative effects and alternative analysis that would be required of an EIS.

As we noted in our comments to the Puget Sound Hatchery DEIS on these issues, in order to evaluate the alternatives for hatchery production, there needs to be a common currency in terms of which each alternative is measured in order that the probable outcomes of adopting one or another of the alternatives can be estimated and compared to one another. The requisite currency must be objective and quantitative if the comparison is to provide a basis for sound and responsible public decision making, as intended by NEPA. Where several objectives are to be pursued—for example, avoiding extinction, preserving the genetic diversity, fitness, and evolutionary potential of the extant wild salmon and steelhead

populations, meeting Federal trust responsibilities to treaty tribes—these objectives must also be interpreted in terms of a common currency that is directly relevant to ESA concerns and evaluated accordingly. The Chambers Creek Draft EA fails to approach the comparison of alternatives in this way.

B. **The Chambers Creek Draft EA Does not Take a Hard Look at the Effects of the Hatchery Programs and Alternatives Thereto.**

The Chambers Creek Draft EA fails to take a hard look at the effects of the hatchery programs and alternatives thereto.

The Chambers Creek Draft EA is deficient because it does not evaluate whether any of the alternatives will satisfy all the requirements for approval under the 4(d) Rule. The Ninth Circuit Court of Appeals has observed:

> "In order to decide what kind of an environmental impact statement need be prepared, it is necessary first to describe accurately the 'federal action' being taken." Thus, just as "where an action is taken pursuant to a specific statute, the statutory objectives of the project serve as a guide by which to determine the reasonableness of objectives outlined in an EIS," so too do the statutory objectives underlying the agency's action work significantly to define its analytic obligations. Put differently, because "NEPA places upon an agency the obligation to consider every significant aspect of the environmental impact of a proposed action," the considerations made relevant by the substantive statute driving the proposed action must be addressed in the NEPA analysis.

Or. Natural Desert Ass'n v. Bureau of Land Mgmt., 625 F.3d 1092, 1109 (9th Cir. 2010) (internal citations omitted). NMFS' proposed approval of the HGMPs is governed by Limit 6 of the 4(d) Rule—50 C.F.R. § 223.203(b)(6). Under this regulation, NMFS may approve the HGMPs where:

> (i) The Secretary has determined pursuant to 50 CFR 223.209 and the government-to-government processes therein that implementing and enforcing the joint tribal/state plan will not appreciably reduce the likelihood of survival and recovery of affected threatened ESUs.
>
> (ii) The joint plan will be implemented and enforced within the parameters set forth in *United States v. Washington* or *United States v. Oregon*.

50 C.F.R. § 223.203(b)(6). The Chambers Creek Draft EA does not include an analysis of whether the alternatives will appreciably reduce the likelihood of survival and recovery of threatened salmonids. Instead, NMFS has indicated that it will make this determination after it receives public comments. This does not fulfill the requirements of NEPA and it frustrates the ability of the public to understand and comment on NMFS' proposed action and alternatives thereto.

A complete and accurate quantitative risk assessment is necessary to fulfill NEPA's mandate to take a "hard look" at the environmental consequences of the hatchery programs. The Chambers Creek Draft EA is deficient for failing to conduct any quantitative risk assessment of the various alternatives. For example, risks to listed salmon and steelhead are neither described in an appropriately quantitative manner, nor in terms clearly related to relevant categories of the ESA, such as take, recovery, risk of extinction, or jeopardy, that are the categories directly relevant to NMFS' evaluation of the HGMPs. Nor are risks described quantitatively in terms of the Viable Salmonid Population ("VSP") parameters or in terms of critical or viable thresholds of abundance.

The Chambers Creek Draft EA fails to provide an appropriately detailed cost-benefit analysis of the subsidy of tribal harvests that is to be provided by the hatchery programs in the three rivers that are the subject of the HGMPs. This is surprising in light of the very low tribal harvest numbers provided in Tables 3.3.1.1, Section 3.3 of each of the HGMPs. Average tribal steelhead harvests in each of the three rivers since 2000/2001 have averaged less than 35 fish for average smolt release levels at or near the levels proposed in each of the HGMPs. This surely warrants a substantive economic cost-benefit analysis that can only occur in the context of an alternatives analysis in an EIS.

The Chambers Creek Draft EA fails to account for the significant "high to moderate" risk of extinction of the majority of Puget Sound steelhead populations, including the Dungeness and Stillaguamish Rivers, described by NMFS' own Puget Sound Technical Recovery Team (PSSTRT 2013, pp. 36 – 89), and the likely similar extinction risk of the Nooksack in view of the lack of spawner and run size trend data noted by the PSSTRT. Thus the EA does not appropriately consider or address the best currently available scientific data.

C. <u>The Action Area is Too Narrow</u>.

NMFS' proposed action area is drawn too narrowly because it ignores the effects that hatchery fish will have outside of the area where the hatchery steelhead would be released. The hatchery fish will travel beyond these areas and harm wild fish far outside of the action area. NMFS should have drawn the action area to include the full range of the hatchery fish to ensure that all of the true effects of the proposed action were considered. At a minimum, NMFS should have considered the recommendation in the recent HSRG Report to Congress (Hatchery Scientific Review Group. 2014. On the Science of Hatcheries: An updated perspective on the role of hatcheries in salmon and steelhead management in the Pacific Northwest) that segregated hatchery programs acclimate and release smolts in lower river reaches to concentrate fishing for returning hatchery adults and reduce the likelihood of uncaught hatchery adults straying onto upstream wild spawning grounds.

D. <u>NMFS Has Relied Upon Faulty Assumptions</u>.

NEPA requires that agencies provide high quality information before making decisions and taking actions. *W. Watersheds Project v. Kraayenbrink*, 632 F.3d 472, 492 (9th Cir. 2011). Yet the Chambers Creek Draft EA relies upon a series of false assumptions and questionable scientific conclusions to analyze and eliminate alternatives from consideration.

The Chambers Creek Draft EA relies on monitoring, evaluation, and adaptive management—some of which is described in the HGMPs that is not funded and not reasonably likely to occur. In particular, NMFS ignores recent information from WDFW regarding its budget for the next biennium that indicates the agency will have to cut its current budget and will have to reduce or eliminate funding for monitoring hatchery impacts.

E. <u>NMFS Cumulative Impacts Analysis is Insufficient</u>.

The Chambers Creek Draft EA is deficient because it does not adequately evaluate cumulative impacts. Notably, NMFS has not addressed the cumulative impacts—such as those to the Puget Sound steelhead DPS and the Puget Sound Chinook salmon ESA—from the cumulative effects of hatchery programs throughout the Puget Sound region.

In addition to the proposed action, agencies must consider other actions, "which when viewed with other proposed actions have cumulatively significant impacts." 40 C.F.R. § 1508.25(a)(2). A cumulative impact is defined as "the impact on the environment which results from the incremental impact of the actions when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such actions." 40 C.F.R. § 1508.7. Cumulative impacts include direct as well as indirect effects, "which are caused by the action and are later in time or farther removed in distance, but are still reasonably foreseeable." 40 C.F.R. § 1508.8(a).

The Chambers Creek Draft EA ignores the long-term foreseeable cumulative impacts of the proposed actions on fish species

The cumulative impacts discussion admits some of the significant adverse effects that climate change will pose to the environment and ESA-listed fish species. Some of these effects, such as increased incidence of disease breakouts and virulence in juveniles, will be exacerbated by the increased effects of disease and pathogens introduced by the hatchery

programs. The Chambers Creek Draft EA's cumulative impacts conclusion is based upon the false assumption that the monitoring and adaptive management program would protect ESA-listed species and mitigate potential adverse cumulative impacts. As these comments explained, the adaptive management and monitoring programs are insufficient and unfunded, and therefore unlikely to occur at all or in a timely enough manner to identify adverse impacts on listed species and take appropriate corrective action. Therefore, the Chambers Creek Draft EA has wrongly relied on these programs to ignore the significant impact of cumulative impacts. As a result, the Chambers Creek Draft EA fails to propose any limitations on the proposed actions or less harmful alternatives.

Finally, the Chambers Creek Draft EA fails to account for the cumulative impacts resulting from other hatchery programs in the Puget Sound region, including other Chambers Creek steelhead hatchery programs. Many of these programs have been operating without 4(d) Rule approval and are currently under review by NMFS.

F. <u>Concerns Regarding the Evaluation of Genetic Risks</u>.

The Estimates of Hatchery-to-Wild Gene Flow and related impacts of segregated steelhead hatchery programs on wild steelhead in the HGMPs and Chambers Creek Draft EA are problematic and incomplete.

There are at least six mechanisms whereby segregated hatchery steelhead programs may cause harm to local wild steelhead populations or other ESA-listed salmonids: 1) direct gene flow (introgression) from returning hatchery-origin adults spawning with wild adults; 2) reduction in the adult abundance of the wild population that results from progeny of hatchery-wild mating surviving to return as adults at lower rates than progeny from wild-wild mating; 3) competitive interactions between wild and hatchery adults on the spawning ground that may result in wild adults spawning in less optimal locations than were no hatchery-origin

adults present on the spawning grounds; 4) competitive interactions in juvenile rearing habitats between progeny of wild-wild mating and progeny of hatchery-wild and hatchery-hatchery mating in the wild resulting in reduced growth and survival of progeny of wild-wild mating; 5) competition and predation from residualized (non-migrating) hatchery smolts on smaller wild juvenile steelhead, Chinook and coho salmon; and, 6) spawning of precocial residulized hatchery smolts with wild adults.

Any of these mechanisms alone or in combination with one another lead to reduced fitness of wild born individuals and reduced abundance and productivity of the local wild population. Each can contribute to preventing or inhibiting the rebuilding of early-returning and/or early spawning wild winter-run steelhead life histories that have been impacted by the past release of CC hatchery smolts and harvest directed at returning hatchery-origin adults. The Chambers Creek Draft EA and the HGMPs are generally silent on the issue of the loss of the early returning component of Puget Sound wild winter-run steelhead populations and fail to account for and address this impact. This is one more reason why these three hatchery programs cannot be appropriately evaluated in the absence of an EIS.

The Chambers Creek Draft EA (Appendix) and the individual HGMPs attempt to address the first mechanism by estimating the extent of past gene flow from each of the Chambers Creek hatchery programs to the respective local wild populations. They do so by relying on two methods developed and employed by WDFW for this purpose, a complex method of analyzing genetic tissue sample data developed by Dr. Ken Warheit and described in a Report by Dr. Warheit dated November 14, 2014 (Warheit Report) and an indirect method based on estimates of wild and hatchery adult return data described by Scott and Gill (2007) in the Washington State Steelhead Management Plan (Scott-Gill method). There are several reservations and potential problems with both methods that render reliance on them by

the HGMPs and the Chambers Creek Draft EA questionable with regard to estimating the degree of risk the three programs pose to their respective wild populations. We devote the reminder of this section of comments to describing the basic concerns with both methods.

1. <u>The Scott-Gill Method</u>.

The Scott-Gill method estimates the maximum potential gene flow from hatchery-wild mating by estimating the proportion of the total number of matings in the wild that occur between wild and stray returning hatchery adults. The total number of matings in the wild include stray hatchery adult males and females mating with one another (HH), wild males and females mating with one another (WW), wild females mating with stray hatchery males and stray hatchery females mating with wild males (HW). Thus, the Scott-Gill method estimates HW/(HH + HW + WW). HW mating can only occur between the proportion of the total spawning time of stray hatchery fish that overlaps in time with the total spawning time of wild fish. The method then assumes (not unreasonably) that the actual proportion of the wild spawning escapement that actually mates with stray hatchery fish will be the result of random mating of between the fraction ON of the total wild spawning escapement that occurs within the period of overlap and the fraction OH of the total stray hatchery escapement that occurs within this period. Where pHOS is the proportion of the total natural spawning escapement that are hatchery strays the proportion PW of the total wild spawning escapement that actually mates with stray hatchery-origin fish is

(pHOS*ON*OH)/[pHOS*OH + (1-pHOS)*ON] (equation (1) on page 107 of the EA).

The actual amount of gene flow from hatchery fish to the wild population from these matings will then depend on the fitness of the offspring produced, the rate at which the progeny survive to return and spawn as adults.

Controversially, WDFW, the authors of the HGMPs, assume that the period of overlap is a small proportion of the total period of spawning of both stray hatchery fish and wild fish. Conventionally and as a matter of recent policy, WDFW (and the HGMPs) assume that wild winter steelhead begin spawning no earlier than March 15 and may extend into early June. The spawning of stray hatchery fish begins in December with the majority of spawning occurring in December and January. Consequently, the HGMPs estimate that ON and OH are each relatively small, on the order of 5%, the values used in the Appendix of the Chambers Creek Draft EA as an example in an effort to illustrate the insignificance of this interbreeding. If pHOS is 5% (the maximum recommended for segregated hatchery programs by the HSRG) and OH and ON are also 5%, the proportion of HW mating would be (0.05*0.05*0.05)/(0.05*0.05 + 0.95*0.05) = 0.000125/0.05 = 0.0025 (.25%, one quarter of one percent).

As the HGMPs, Chambers Creek Draft EA, and others have noted it may be very difficult to conduct field surveys of steelhead spawning during the entire span of time of spawning by winter steelhead. But WDFW's assumption that no wild spawning occurs in Puget Sound rivers and streams prior to March 15 is not based on strong empirical evidence because no effort has been expended in the recent past or currently to survey steelhead spawning streams between December and the middle of March and to attempt to determine the origin (hatchery or wild) of steelhead spawning during this period. After March 15, spawning surveys are either aerial surveys or estimates based on estimates of total returns and harvest, not systematic ground-base surveys intended to document actual spawning activity much less attempt to identify spawning involving stray hatchery males and females.

As part of these comments, we are submitting two documents with data pertaining to this issue: a monograph titled "The reproductive ecology of *Oncorhynchus mykiss* in tributary

streams of the mid Skagit River Basin" by Mr. Bill McMillan, and a Master of Science thesis at the School of Fisheries and Aquatic Sciences at the University of Washington "Hatcheries, phenology, and families: juvenile steelhead ecology in Forks Creek, Washington" by Ms. Marissa H. Jones, on whose Committee Dr. Warheit served. The McMillan monograph provides data for tributaries of the middle Skagit River showing significant spawning of wild steelhead as early as January, spawning by female hatchery steelhead with resident and/or wild males. Chapter 1 of the Jones thesis provides data based on genetic samples from 602 juvenile steelhead sampled from rearing locations throughout the Forks Creek basins showing that over 30% were hybrid offspring of Chambers Creek origin hatchery fish from the Forks Creek hatchery and wild steelhead. The comments submitted by Tout Unlimited (authored by John McMillan) on the Puget Sound Hatchery DEIS present additional data that cast doubt on the unverified assumption of a narrow period of overlap between the spawning times of stray CC hatchery and wild steelhead.

The Scott-Gill method also does not account for spawning by precocial (sexually mature) male residual hatchery smolts that become resident fish that spawn as "sneaker males" with wild female steelhead. The method also treats all "wild" or natural-origin steelhead that are assumed to be in the post-March 15 period of spawning as pure wild fish, that have not recently been introgressed by hatchery genes. But surviving progeny of either HH or HW mating in the previous generation may return and spawn within the same period of time as do wild steelhead, whether or not this period extends prior to March 15. Some or all of these putatively wild fish will spawn within the period of wild spawning that does not overlap with stray hatchery spawning, whatever that latter period may truly be, but they will be erroneously classified by the method as "wild" spawners.

Finally, the Scott-Gill method does not recognize the demographic impact to wild steelhead populations from HW spawning and the lower fitness that progeny of these matings are likely to have. Despite the cynical attempt in the Appendix of the Chambers Creek Draft EA to ridicule the importance of this matter (Chambers Creek Draft EA, pp. 106-108), wild steelhead that spawn with hatchery fish at the expense of spawning with wild steelhead (the only mechanism after all by which hatchery gene flow to the wild population can occur) will produce fewer returning adult offspring to contribute to the productivity and abundance of the wild population in the future than they would have had they instead spawned with a wild steelhead. The HGMPs and Chambers Creek Draft EA acknowledge (as does Dr. Warheit in the Warheit Report) that progeny of HW (and also HH) mating will survive at a lower rate than progeny of WW mating. This rate is most likely no greater than 50% the rate of progeny of WW mating and perhaps as low as 5% (The Warheit Report employs a lower estimate for this rate of 8.4%; the HGMPs adopt this value for progeny of HH spawners and adopt a range between 8.4 and 54% for progeny of HW spawners). The absolute number of wild adults that are lost to this process will certainly depend on the extent of the period of overlap between hatchery and wild spawning times, as the Appendix to the Chambers Creek Draft EA argues. But that does not at all alter the fact that this is a numeric loss to the wild population that affects both the abundance and the productivity of the wild population and must be accounted for as one of the impacts from hatchery-to-wild gene flow. And as the data we provide in supporting documents and comments submitted by others shows, the harmful impact from this process alone is likely to be considerable. It will be particularly damaging to small populations like the Dungeness.

All three HGMPs addressed in the Chambers Creek Draft EA employ this method (in section 2) to provide estimates of gene flow from the hatchery to the wild steelhead

population. All rely upon the policy assumption that no wild spawning occurs prior to March 15 and that little if any hatchery spawning occurs after March 15. This assumption is not supported by any appropriately detailed on-the-ground surveying of steelhead spawning prior to March 15 or the composition of spawners as to hatchery or wild origin of any surveys that are conducted prior to March 15. As described in McMillan 2015 and comments submitted by Tout Unlimited (authored by John McMillan) on the Puget Sound Hatchery DEIS, this assumption is false and the magnitude of the error may be considerable. Any such error would result in an under-estimation of gene flow from the hatchery to the wild population.

The extent of gene flow estimated by the Scott-Gill method is likely to be under-estimated even were the period of overlap is narrow as assumed by WDFW policy. This is because the timing of river-entry and spawning of natural-origin (F1 or later generation) spawners that were progeny of HH spawning in the wild and those that were progeny of HW spawning will be similar if not identical to that of wild (WW) spawners. While returning adults produced in the hatchery may return early and may spawn in the wild early (in December or January), the return timing of progeny from natural spawning will be determined to a significant extent by the water temperatures they experienced during incubation and early rearing in the river. This will result in the majority of such (HH and HW) progeny returning later than fish produced in the hatchery. If, in fact, it were true that all wild, natural-origin spawning does not occur prior to March 15, it will be highly probable that progeny of HH and HW mating in the wild will also not spawn earlier than March 15, and thus will overlap completely with the wild population. However, the Scott-Gill method ignores this by simply assuming that any spawner that spawns after March 15 is wild fish (the result of WW spawning in the preceding generation). By relying on these assumptions, the HGMPs under-estimate the potential gene flow from the hatchery to the wild population.

For these reasons, the Scott-Gill method as employed in each of the HGMPs and Chambers Creek Draft EA is very likely to under-estimate hatchery-to-wild gene flow in addition to failing to account for the demographic impact of the lower reproductive success of progeny of HH and HW mating in the wild.

2. **The Warheit Method.**

The Warheit Report is a technically complicated analysis aimed at improving the accuracy of estimates of hatchery-to-wild gene flow (introgression) based on genetic sample data used in the model-based genetic clustering program STRUCTURE. The analysis is creative and certainly holds promise to improve the accuracy of estimates of gene flow when, as is currently the case, reliance must be placed on less-than-ideal data. However, the methods developed by Dr. Warheit remain to be perfected and currently there are shortcomings to the analyses that need to be addressed before the estimates reported in Section 3 of the Report and two of the three HGMPs (Nooksack/Kendall Creek and Stillaguamish/Whitehorse Ponds), and relied upon in the Chambers Creek Draft EA, can be taken at face value. In addition, as noted in the Appendix to the Chambers Creek Draft EA, the method has not yet been subjected to a proper independent peer review. We note several issues that warrant further examination. Our primary concern with the methods developed in the Report is that they are do not take a complete account of the key uncertainties in the estimated values of gene flow estimated by the method and as a consequence are insufficiently risk-averse with respect to the viability of the affected wild steelhead populations.

First, the method described in Section 1 to estimate the level of genetic diversity between the original wild Chambers Creek steelhead populations (from which the segregated hatchery stock was founded) and northern Puget Sound wild steelhead populations at the time

of the development of that hatchery stock in 1950 likely under-estimates that diversity. As Dr. Warheit explains, it is important to estimate the level of genetic diversity between wild Puget Sound steelhead populations immediately prior to the widespread release of Chambers Creek origin hatchery fish in order to estimate the extent to which that diversity has been reduced by gene flow from the segregated hatchery stock to wild steelhead populations. If this "historic" level of diversity can be credibly estimated, the assignment error that arises when STRUCTURE is used to estimate gene flow and that is caused by the genetic similarity resulting from post-1950 hatchery gene flow can be corrected. Dr. Warheit undertakes to accomplish this by simulating ancestral populations and their divergence from one another at various points in time, beginning with a single post-glacial parental population and terminating in 1950 with three wild populations representing 1) northern Puget Sound winter steelhead, 2) Chambers Creek winter steelhead, and 3) lower Columbia River summer-run steelhead. From these three populations, three introgressed populations created from pairings of the three base populations are created. These six simulated populations are used in Section 2 to test the accuracy of STRUCTURE in estimating introgression.

The main problem with this exercise is the basis on which the target level of genetic diversity (measured by Fst between the three populations across all SNP loci used in the simulation) at the end of the simulation (representing 1950, the "pre-hatchery" phase) is determined. The critical level of diversity is that between the simulated northern Puget Sound and Chambers Creek populations. Dr. Warheit appears to use the level represented by recent empirical samples from northern Puget Sound populations that likely have had their historic diversity reduced by introgression by Chambers Creek hatchery steelhead since 1950 and also, perhaps, from genetic drift due to reductions in effective from reductions in census populations since 1950.

The reported level of diversity between Chambers Creek hatchery and northern Puget Sound wild steelhead of Fst approximately 0.02 is likely much smaller than it was in 1950. The lower the true pre-hatchery phase Fst between Chambers Creek and North Puget Sound wild steelhead the more difficult it will be for STRUCTURE to estimate admixture (introgression by hatchery genes) and the more difficult it will be to account and correct for assignment error. The greater the true pre-hatchery phase level of Fst between the two populations is, the more accurate STRUCTURE estimates of admixture will be and the easier it will be to identify and correct the assignment error.

A preferable approach would be to examine other data for wild steelhead to determine the general pattern of Fst versus distance-between-populations. At the very least a sensitivity analysis should be conducted that repeats the simulations of section 1 using a number of historically plausible Fst values greater than 0.02, up to at least 0.08. For example, the recent papers by Garza et al 2014 on the genetic diversity of California steelhead (cited in the Warheit Report) and by McPhee et al 2007 and 2014 on Kamchatka steelhead provide information of Fst between wild steelhead populations and distances. Both provide evidence that Fst values between steelhead populations separated by distances equal to those by which northern Puget Sound populations are separated from Chambers Creek are generally greater than 0.02 or 0.03.

Section 1 of the report then employs the simulated population data from Section 1 to estimate various error rates when STRUCTURE is used to estimate introgression. By identifying the errors (since the true values of every individual in each of the simulated populations is known with certainty) one can then consider how best to correct the nominal STRUCTURE assignments to minimize if not eliminate the errors. Essentially, Dr. Warheit identifies a cutoff point for the level of introgression estimated by STRUCTURE for each

individual above which to consider an individual as introgressed and below which to consider it as pure wild or pure hatchery.

This approach to correcting STRUCTURE assignments for known or estimable kinds of estimation error is important. However, what is not discussed by Dr. Warheit or by NMFS in its discussion of the report in the Appendix of the Chambers Creek Draft EA is that any criterion for determining a cut-off point for determining introgression will involve a *policy decision*. This policy decision should reflect the priority managers assign to making or not making one or another kind of error. Dr. Warheit chooses a standard statistical criterion to reduce the mean squared overall assignment error (OER) (including a weighted "No Call" error rate that can be ignored in this context). This criterion treats each type of assignment error as equally good or bad. For example, failing to assign a hatchery fish to the hatchery group is as bad as failing to assign and admixed (HW) individual to the HW group. When the primary conservation issue is to protect wild steelhead from introgression from hatchery fish, and when perfect correction of all possible types of assignment error is not possible, a *management policy* choice must be made regarding the most appropriate way to minimize the worst kind of error. This is unlikely to be minimizing OER. In any event an explicit sensitivity analysis of several different criteria for identifying the cutoff threshold needs to be examined. This, of course, requires repeating much of the analysis of the entire report for each different candidate criterion. But, given the approach of the report, this simply must be done to identify the best approach to correcting the errors that are of concern.

Section 2 of the report is technically the most difficult. Its principal objective is to develop an approach to using the estimates of expected assignment errors from the simulated data in Section 1 to adjust STRUCTURE estimates of introgression from actual empirical genetic samples. The method relies on resampling data simulated using actual sample data

from Puget Sound steelhead populations and estimate assignment errors (using the cutoff value estimated in Section 1) for these data using a linear regression on the re-sampled simulated data and maximum likelihood estimation of the regression parameters. Confidence limits on the Maximum likelihood value (MLE) of the estimated error rates are also estimated. What is produced is a MLE point estimate of the level of introgression for each individual in each sample analyzed. This is the estimated level of introgression (from the STRUCTURE analysis) using the cutoff value estimated in Section 1, but now with a set of confidence limits attached.

Our concern with Section 2 is twofold. First, the maximum likelihood approach does not properly represent the uncertainty of the estimate of the level of introgression. The confidence limits surrounding the MLE point estimate only reflect how well the point estimate is estimated. It says nothing about the probability of the MLE, other than that it is a maximum given all of the assumptions surrounding the particular statistical procedure that produced the point estimate. It does not provide information, for example, about the probability that the actual level of introgression is 10% greater or less than the MLE point estimate. To properly judge the uncertainty of the estimated level of introgression – and thus the risk to wild steelhead posed by introgression – a probability distribution of the level of introgression (whose maximum value may be the MLE point estimate) is needed. The second concern we have is that the report considers to "call" any MLE point estimate of introgression whose 90% confidence intervals (C.I.) are greater than 0.25 "uncertain". But no explicit description of what this actually means in a management context accompanies this decision.

The implication in the context of the use of this approach to the actual population data in Section (an reported in the Kendall Creek and Whitehorse Ponds HGMPs) is that any such point estimate is equivalent to zero (i.e., no introgression), and certainly any point estimate

whose lower CI is equal to or less than 0. While Dr. Warheit does not explicitly state this, it is left open to managers to do so. Again, such a management interpretation requires an explicit *policy decision*, one which would be highly debatable, and one which NMFS should therefore question and scrutinize very closely – but does not. Further, an alternative probabilistic analysis of the error of estimating the level of introgression would permit a more informed management decision of how to treat estimates of introgression level that have broad distributions. Consider, for example, an error-corrected estimate of introgression with a most probable value of 0.15 that had a normal distribution with 5% of the left tail of the distribution below 0 and 5% of the right tail above 30%. It would make sense to ask, "what is the probability that the level of introgression is less than 10% or greater than 25%". The likelihood method developed in section 2 and employed on the real data in section 3 simply does not adequately reflect the remaining uncertainty and permit it to be accounted for in a risk-averse way. These shortcomings are correctable, but require considerably more research and exploratory analyses. In view of the risk that introgression poses to wild Puget Sound steelhead, NMFS should be more cautious in its acceptance of the results reported in section 3 of the report and in the two HGMPs.

V. The HGMPs Do Not Meet the 4(d) Rule Requirements.

A. The HGMPs do not Comply with the Limit 5 Criteria.

NMFS' regulations require that public comment be taken as to whether HGMPs submitted as part of a joint plan under Limit 6 of the 4(d) Rule meet the criteria of Limit 5. NMFS' 4(d) Implementation Guidance indicates that NMFS will evaluate HGMPs submitted under Limit 6 in the same manner as it evaluates HGMPs submitted under Limit 5. NMFS should decline to approve the joint plan because the HGMPs do meet the criteria of Limit 5 of the 4(d) Rule.

1. **The HGMPs do not have Clearly Stated Objectives.**

The first criterion of Limit 5 of the 4(d) Rule requires that:

> The HGMP has clearly stated goals, performance objectives, and performance indicators that indicate the purpose of the program, its intended results, and measurements of its performance in meeting those results. Goals shall address whether the program is intended to meet conservation objectives, contribute to the ultimate sustainability of the natural population, and/or intended to augment tribal, recreational, or commercial fisheries. Objectives should enumerate the results desired from the program that will be used to measure the program's success or failure.

50 C.F.R. § 223.203(b)(5)(i)(A). The HGMPs submitted as part of the joint plan do not meet these requirements.

All HGMPs state goals and objectives in vague, general terms and phrases that ignore relevant and substantive biological issues that arise in conservation contexts.

Regarding the preservation of genetic diversity, which is a fundamental and critical performance and monitoring variable, none of the HGMPs provide specifics regarding the kind(s) of genetic markers to be measured, how many loci for each marker are to be measured, what genetic parameters are to be monitored using the markers (expected and observed levels of heterozygozity, allelic richness, etc.), and what target levels of genetic parameters are to be achieved. As a result, none of the HGMPs can state what corrective actions will be taken when target levels of genetic diversity are not attained.

Moreover, none of the HGMPs provide any substantive text that explains the relationship of listed performance indicators to associated performance standards and goals. No proper justification is provided for the indicators and standards. Rather, goals, standards, and indicators are largely simply asserted.

2. **The HGMPs do not Utilize the Concepts of Viable Salmonid Populations.**

The second criterion of Limit 5 of the 4(d) Rule requires that:

> The HGMP utilizes the concepts of viable and critical salmonid population threshold, consistent with the concepts contained in the technical document entitled "Viable Salmonid Populations" (NMFS, 2000b). Listed salmonids may be purposefully taken for broodstock purposes only if the donor population is currently at or above the viable threshold and the collection will not impair its function; if the donor population is not currently viable but the sole objective of the current collection program is to enhance the propagation or survival of the listed EUS; or if the donor population is shown with a high degree of confidence to be above critical threshold although not yet functioning at viable levels, and the collection will not appreciably slow the attainment of viable status for that population.

50 C.F.R. § 223.203(b)(5)(i)(B). The HGMPs submitted as part of the joint plan do not adequately utilize the Viable Salmonid Population ("VSP") concepts and do not meet these requirements.

The three HGMPs (in section 2.2.2) state the preliminary critical and viable abundance thresholds identified by the Puget Sound Steelhead Technical Recovery Team. However, the HGMPs fail to note that these thresholds apply to a recovered population and do not discuss how these abundance levels should be related to the current depressed conditions of the populations. As already noted in these comments, in the absence of a Puget Sound-wide steelhead recovery plan, it is impossible to accurately related the current abundance of wild steelhead in each of the three rivers to interim recovery thresholds and to appropriately evaluate the impacts of the proposed Chambers Creek hatchery programs on the role each population may have in the recovery of the Puget sound steelhead DPS.

3. <u>The HGMPs do not Minimize Harm to Wild Populations</u>.

The fifth criterion of Limit 5 of the 4(d) Rule requires that:

> The HGMP evaluates, minimizes, and accounts for the propagation program's genetic and ecological effects on natural populations, including disease transfer, competition, predation, and genetic introgression caused by the straying of hatchery fish.

50 C.F.R. § 223.203(b)(5)(i)(E). The HGMPs submitted as part of the joint plan do not meet these requirements.

The steelhead programs do not adequately acknowledge the risk of fitness loss that is likely to be caused by the steelhead program and, therefore, does not consider appropriate monitoring and measures to detect and avoid such impacts. The HGMPs are also silent on the possible impacts on wild steelhead of the fisheries targeting hatchery steelhead in each of the three rivers. The HGMPs note that recreational fisheries are catch-and-release (C&R), but do not discuss either C&R mortality or the impact of C&R on the reproductive success of steelhead, despite significant relevant literature on Atlantic salmon showing impaired reproductive success steelhead-sized adults caught and released (Richard et al. 2013 and references therein). Nor do the HGMPs acknowledge the fact that tribal net fisheries (and also perhaps hook-and-line fisheries) are non-selective and that tribal catch likely includes wild steelhead. The HGMPs do not provide any information regarding how the tribal catch is monitored, including whether or not WDFW staff are able to visually inspect any of the tribal catch that may be reported to them.

4. <u>The HGMPs Lack Adequate Monitoring and Evaluation</u>.

The eighth criterion of Limit 5 of the 4(d) Rule requires that:

> Adequate monitoring and evaluation exist to detect and evaluate the success of the hatchery program and any risks potentially impairing the recovery of the listed ESU.

50 C.F.R. § 223.203(b)(5)(i)(H). The HGMPs do not meet these requirements.

There is not adequate monitoring and evaluation of the hatchery programs' success and risks to listed species.

5. <u>The HGMPs do not Include Adequate Adaptive Measures</u>.

The ninth criterion of Limit 5 of the 4(d) Rule requires that:

> The HGMP provides for evaluating monitoring data and making any revisions of assumptions, management strategies, or objectives that data show are needed.

50 C.F.R. § 223.203(b)(5)(i)(I). The HGMPs do not meet these requirements.

The failure of the HGMPs to identify relevant measureable genetic and life history parameters and to specify corresponding quantitative threshold or target levels to avoid risks to listed populations means that no adaptive measures exist for altering program practices in the light of data. Even were some adaptive measures provided, the absence of adequate and/or assured funding of the essential monitoring activities means that the data necessary to implement adaptive measures will not be obtained in an appropriately timely manner, which is tantamount to having no adaptive management at all. However, in general the HGMPs provide no explicit set of decision procedures or protocols by which monitoring data will be acquired, analyzed, and by which program practices are to be changed based on the results of those analyses.

B. The Joint Plan Does not Meet the "No Jeopardy" Standard.

The HGMPs submitted under Limit 6 of the 4(d) Rule as a joint plan may be approved only if the implementation and enforcement of the joint plan will not appreciably reduce the likelihood of survival and recovery of affected threatened ESUs. 50 C.F.R. § 223.203(b)(6)(i). The submitted HGMPs do not meet this requirement. In the absence of an approved Puget Sound-wide steelhead recovery plan, it is arguably impossible to determine that any level of release of Chambers Creek-origin hatchery steelhead into any of the three rivers for which HGMP approval is sought will not jeopardize the Puget Sound steelhead DPS.

VI. Incorporation of Documents.

In addition to the comments provided herein, the Commenters hereby incorporate with this reference the comments of Bill McMillan submitted May 3, 3015, and the materials

attached hereto. These comments and materials provide further details regarding the issues and concerns addressed herein.

Thank you for your consideration of these comments.

CITED MATERIAL

HSRG 2014. HSRG (Hatchery Scientific Review Group). 2014. On the Science of Hatcheries: An updated perspective on the role of hatcheries in salmon and steelhead management in the Pacific Northwest. A. Appleby, H.L. Blankenship, D. Campton, K. Currens, T. Evelyn, D. Fast, T. Flagg, J. Gislason, P. Kline, C. Mahnken, B. Missildine, L. Mobrand, G. Nandor, P. Paquet, S. Patterson, L. Seeb, S. Smith, and K. Warheit. June 2014.

PSSTRT 2013. Puget Sound Steelhead Technical Recovery Team (PSSTRT). 2013. Viability Criteria for Puget Sound Steelhead. Final Review Draft. 373 p.

Richard, A., M. Dionne, J. Wang, L. Bernatchez. 2013. Does catch and release affect the mating system and individual reporductive success of wild Atlantic salmon (*Salmo salar L.*)? Molecular Ecology 22: 187 – 200.

McMillan, Bill. 2015. The reproductive ecology of *Oncorhynchus mykiss* in tributary streams of the Mid Skagit River Basin.

McMillan, Bill. 2015. Excel spreadsheet: Nooksack stillaguamish dungeness harvest-hatchery history_4-27-2015.xls.

Jones, M.H. 2014. Hatcheries, phenology, and families: juvenile steelhead ecology in Forks Creek, Washington. A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science, University of Washington.

ATTACHMENTS

A. Statement of Scientists Regarding Risks Posed by Chambers Creek Hatchery Steelhead Programs to the Recovery of Wild Puget Sound Steelhead;

B. First Declaration of Gordon Luikart;

C. First Declaration of Jack A. Stanford;

D. Comments on Puget Sound Hatchery Program DEIS by Trout Unlimited (Jan. 23, 2015);

E. The Reproductive Ecology of *Oncorhynchus mykiss* in Tributary Streams of the Mid Skagit River Basin, Bill McMillan (DRAFT of Jan. 15, 2015).

ATTACHMENT A

Statement of Scientists Regarding Risks Posed by Chambers Creek Hatchery Steelhead Programs to the Recovery of Wild Puget Sound Steelhead

May 4, 2015

As scientists with expertise in aquatic ecology, fisheries management, and conservation genetics, we wish to make public our understanding of the threats that Chambers Creek hatchery steelhead programs pose to the recovery of wild steelhead in Puget Sound. These programs are the majority of winter run steelhead hatchery programs throughout Puget Sound, and are intended to provide adult fish for harvest. They do not have a role in the conservation or recovery of Puget Sound's ESA-listed wild steelhead and salmon populations; to the contrary, they can compromise wild steelhead recovery efforts.

Washington State's Chambers Creek/Early winter hatchery steelhead programs are typical of hatchery programs using domesticated broodstock. Chambers Creek hatchery steelhead have been domesticated (adapted to captivity) as a result of having been selected over many generations for optimal performance in the hatchery. Artificial selection for performance in a hatchery, however, comes at a significant cost to the ability to survive and reproduce successfully in the wild environment. As a result, these hatchery fish are less fit to complete a life cycle in the wild, and so are their offspring.

Chambers Creek hatchery steelhead are not produced to help conserve wild populations; they are intended either to be harvested by fishers or to serve as broodstock for the next generation of hatchery fish. Nevertheless, many of these hatchery origin steelhead escape to wild steelhead spawning grounds where they can pass on genes to the wild population. When this happens, the resulting offspring are less likely to survive and reproduce in the wild than the offspring of wild fish. Because the abundance of wild Puget Sound steelhead has been substantially reduced, even a few of these hatchery fish spawning in the wild can have a significant negative effect. Over time, this results in a steady erosion of returning wild steelhead abundance and diversity.

Washington State's Chambers Creek hatchery steelhead programs have been among the most prominent production hatchery programs of Puget Sound since the early 1970s, and today are the most common winter steelhead hatchery programs in Puget Sound. Chambers Creek hatchery fish are also among the most strongly selected fish for adaptation to captivity, and thus likely have strong negative effects following introgression into wild populations. We believe and research shows that when Chambers Creek hatchery steelhead spawn in the wild they can cause significant harm to wild Puget Sound steelhead populations. For these reasons, we as scientists publically acknowledge that Chambers Creek/early winter hatchery steelhead programs pose an avoidable threat to the recovery of Puget Sound ESA-listed wild steelhead. We do so as professional scientists, not claiming to represent the views or beliefs of our employers.

The concerns stated in this document are confined to the existing Chambers Creek hatchery steelhead programs and should not be interpreted in any way as a blanket statement about hatcheries.

A list of recent peer-reviewed scientific publications supporting our concerns with Chambers Creek hatchery steelhead may be found at http://wildfishconservancy.org/wild-steelhead/supporting-literature-for-steelhead-hatchery-sign-on-letter.

Dr. Jack Stanford, Bierman Professor of Ecology & Director
Flathead Lake Biological Station
University of Montana

Jim Lichatowich
Fishery Biologist & Award-winning Author

James R. Karr, Professor Emeritus
School of Aquatic and Fishery Sciences
University of Washington

Stephen C. Conroy, Ph.D.

Bill McMillan
Field Biologist, retired

Todd Sandell, M.S., Ph.D.
Senior Ecologist
Wild Fish Conservancy

Patrick Trotter, Ph.D.
Consulting Biologist

Nick Gayeski
Fisheries Scientist
Wild Fish Conservancy

Jamie Glasgow, M.S.
Biologist
Wild Fish Conservancy

James Fletcher, M.S.
Ecologist
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Matt Stoecker
Consulting Biologist
Stoecker Ecological

Peter Bahls
Fish Biologist
Northwest Watershed Institute

Bill Bakke
Fish Biologist

Norman Baker, Ph.D.
Sierra Club

Christopher Frissell, Ph.D.
Research Ecologist

Jeffrey Dose
Fisheries Biologist, retired

Walter Duffy
Adjunct Professor
Dept. of Fisheries Biology, Humboldt State University

Craig Orr Ph.D.
Conservation Advisor
Watershed Watch Salmon Society

William Atlas
Simon Fraser University

Ray J. White, Ph.D.
Consulting Fishery Biologist

Bob Hooton
Fisheries Biologist, retired
Formerly, Province of British Columbia

Aaron Hill
Executive Director
Watershed Watch Salmon Society

Charles Kimmel
Professor Emeritus
University of Oregon

Robert C. Wissmar, Professor Emeritus
School of Aquatic and Fishery Sciences
University of Washington

Dennis Thireault, MS
Puget Sound Projects LLC
Environmental Regulatory Policy Consultant

Richard Nawa
Staff Ecologist
Klamath Siskiyou Wildlands Center

ATTACHMENT B

HONORABLE THOMAS S. ZILLY

UNITED STATES DISTRICT COURT
WESTERN DISTRICT OF WASHINGTON
AT SEATTLE

WILD FISH CONSERVANCY, Plaintiff, v. PHIL ANDERSON, in his official capacity as the Director of Washington Department of Fish and Wildlife, *et al.*, Defendants,	)	No. 2:14-CV-00465-TSZ FIRST DECLARATION OF GORDON LUIKART

I, Gordon Luikart, declare the following to which I am competent to testify under penalty of perjury of the laws of the United States:

1. My address is 41229 Haystack Mountain Lane, Polson, Montana 59860. I have been retained as an expert on salmonid genetics by the Plaintiffs in this matter;

PROFESSIONAL QUALIFICATIONS

2. I have 20 years of professional experience researching and teaching at the college and university level. Since 2000, I have specialized in research and teaching in the area of animal conservation, ecology, and population genetics/genomics;

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3. From 1997-2000, I was a postdoctoral research scientist in Europe working on large (five country) animal genetics projects funded by the European Union and also NSF-NATO. I received a Ph.D. in Organismal Biology and Ecology in 1997 and a M.S. in Zoology in 1992, both from the University of Montana (but including a year in Australia on a Fulbright fellowship). I received a Bachelor of Science degree in Biology from Iowa State University in 1988, with a minor in Animal Ecology;

4. Since 2005 I have spent part of my years researching and teaching as a visiting professor and senior research scientist at the Center for Investigation of Biodiversity and Genetic Resources at the University of Porto, in Portugal. For the last three years, I have spent the majority of each year researching and teaching as an associate professor at the University of Montana's Flathead Lake Biological Station. Courses I teach include advanced graduate level and undergraduate level wildlife genetics/genomics classes;

5. I have conducted genetic research on fish and wildlife populations in several different countries in addition to the United States and Portugal, including in Australia as a Fulbright Fellow, and in France as a government scientist where I won the bronze medal as a top researcher with the Centre National de la Recherche Scientifique. I have researched a wide range of species, including goats and other ungulates, carnivores, fish, and other aquatic species;

6. My research and teaching embraces various topics related to animal genetics/genomics, including disease diagnostics (via pathogen DNA testing), population genetics, modeling, captive and domesticated populations, endangered and threatened species recovery, effects of gene flow and hybridization (introgression) on individual fitness, population size and structure, local adaptation, and monitoring of the genetically-effective population size and the effective number of breeders using genetic markers in natural populations;

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7. I have conducted numerous research investigations on these subjects. Serving as a principal or co-principal investigator on more than 40 scientific research projects, my work has produced chapters in four books, all relating to wildlife population genetics (one on animal domestication), and over 100 scientific papers in peer-reviewed international journals. I recently (2007) co-authored a major textbook on conservation genetics (the second edition of was published in 2014, that contains updated sections relevant to salmon hatcheries, introgression, and their effects on effective population size and fitness on wild stocks);

8. My recent research projects involved developing a computer program simulator to model landscape level gene flow for aquatic species in complex river systems peer-reviewed publications on DNA sequencing and gene flow in trout and salmon, and in wild and domestic populations (including development of novel estimators of the number of breeders (spawners per generation) from genetic marker data);

9. My scholarship includes service on the editorial board of the journal Conservation Biology and as an associate editor for both Molecular Ecology Resources and the Journal of Heredity;

10. In the last five years I was recruited as an advisor for the Swan Ecosystem Center Native Fish Committee, and I have been a member of the American Fisheries Society, the Ecological Society of America, the Society for Conservation Biology, the Society for the Study of Evolution, the Wildlife Disease Association, and the Wildlife Society;

11. Attached hereto as Exhibit 1 are my curriculum vitae, which include a list of all peer-reviewed publications I have authored since 1996;

12. I have substantial familiarity with the genetics of animal domestication, adaptation to captivity, the effects of gene flow and introgression on fitness and population

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persistence in fish and wildlife, local adaptation in salmonids, and statistical and molecular empirical genomics;

13. I have not testified as an expert at trial during the last four years. I have testified as an expert at a deposition during the last four years in the following proceeding: *Wild Fish Conservancy, et al. v. National Park Service, et al.*, W.D. Wash. No. 3:12-CV-05109-BHS.

14. I am being compensated for my work on this matter. My cost per hour is approximately $122, and I have worked for approximately eight (8) hours at this point;

15. In addition to drawing upon my knowledge and experience, I have reviewed the documents cited throughout this declaration and the following documents in developing my opinions expressed herein:

a. Hatchery and Genetic Management Plan, Kendall Cr. Winter Steelhead Hatchery Program, Washington Department of Fish and Wildlife (WDFW), updated February 10, 2014 (Nooksack River HGMP);

b. Hatchery and Genetic Management Plan, Marblemount Winter Steelhead Hatchery Program, WDFW, updated February 10, 2014 (Skagit River HGMP);

c. Hatchery and Genetic Management Plan, Snohomish Basin Winter Steelhead Hatchery Program, WDFW, updated February 10, 2014 (Snohomish River HGMP);

d. Hatchery and Genetic Management Plan, Whitehorse Ponds Winter Steelhead Hatchery Program, WDFW, updated February 10, 2014 (Stillaguamish River HGMP);

e. Hatchery and Genetic Management Plan, Dungeness River Early Winter Steelhead Hatchery Program, WDFW, updated February 7, 2014 (Dungeness River HGMP);

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f. Hatchery and Genetic Management Plan, Soos Creek Hatchery Winter Steelhead Hatchery Program, WDFW, updated January 3, 2014 (Duwamish/Green River HGMP);

g. A letter dated April 14, 2010, from George Pess, Jim Myers, and Jeff Hard of National Marine Fisheries Service's (NMFS) Northwest Fisheries Science Center to the Lower Elwha Klallam Tribe;

h. Impact of Hatchery Steelhead Smolt Release Levels on Wild and Hatchery Steelhead Survival Rates: Final Administrative Report, Saltonstall-Kennedy Project # NA08NMF4270424, April 11, 2013;

i. Ecological, Genetic and Productivity Consequences of Interactions between Hatchery and Natural-Origin Steelhead of the Skagit Watershed, March 2013;

j. "Historical abundance of Puget Sound steelhead, *Oncorhynchus mykiss,* estimated from catch record data" by N. Gayeski, B. McMillan, and P. Trotter published in the Canadian Journal of Fisheries and Aquatic Sciences, volume 68, pages 498 – 510, 2011;

k. NOAA Fisheries 2007 Puget Sound Steelhead Status Review, NOAA Technical Memorandum TM81. Hard, J.J., J.M. Myers, M.J. Ford, R.G. Cope, G.R. Pess, R.S. Waples, G.A. Winans, B.A. Berejikian, F.W. Waknitz, P.B. Adams. P.A. Bisson, D.E. Campton, and R.R. Reisenbichler. 2007, Status review of Puget Sound steelhead *(Oncorhynchus mykiss),* U.S. Dept. Commer., NOAA, Tech. Memo. NMFS-NWFSC-81, p. 117;

l. Summary of hatchery-wild introgressive hybridization for northern Puget Sound steelhead (*Oncorhynchus mykiss*) populations affected by segregated hatchery programs,

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Report by Kenneth I. Warheit, Washington Department of Fish and Wildlife, Unpublished report, Washington Department of Fish and Wildlife, Draft March 17, 2014;

m. "Viability Criteria for Puget Sound Steelhead: Final Review Draft" by the Puget Sound Steelhead Technical Recovery Team (PSSTRT), Jeffrey J. Hard, James M. Myers, Edward J. Connor, Robert A. Hayman, Robert G. Kope, Gino Lucchetti, Anne R. Marshall, George R. Pess, and Bradley E. Thompson, dated April 2013;

n. McLean, Jennifer, P. Bentzen, and T. P. Quinn. 2003. Differential reproductive success of sympatric, naturally spawning hatchery and wild steelhead trout (*Oncorhynchus mykiss*) through the adult stage. Canadian Journal of Fisheries and Aquatic Sciences, 60: 433 – 440;

o. McLean, Jennifer, P. Bentzen, and T. P. Quinn. 2004. Differential reproductive success of sympatric, naturally spawning hatchery and wild steelhead trout *Oncorhynchus mykiss*. Environmental Biology of Fishes, 69: 359 – 369;

16. I have also spoken with the following people in forming my opinions expressed herein: Dr. Fred Allendorf, Dr. Robin Waples, Dr. Jack Stanford, Dr. Shawn Narum, and Nick Gayeski;

SUMMARY OF OPINIONS

17. In summary, it is my professional opinion that:

a. WDFW's releases of Chambers Creek-origin hatchery winter steelhead smolts into rivers of Puget Sound , including those described in recently-revised Hatchery and Genetic Management Plans (HGMPs) prepared by WDFW, produce returning adults that have significantly lower fitness (survival and reproduction) in the wild than native wild-origin steelhead;

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b. a significant number of returning adults from those Chambers Creek steelhead releases are not and will not be caught in fisheries nor return to hatchery racks but will instead stray onto the spawning grounds of Puget Sound wild-origin steelhead populations, which are a threatened species under the Endangered Species Act (ESA), where a substantial proportion of them likely interbreed with native wild-origin steelhead;

c. this interbreeding results in the spreading of maladaptive genes from the hatchery fish to the native wild-origin populations resulting in significantly lower survival and reproductive fitness and reduced local adaptation potential (i.e., the ability to adapt to environmental change such as climate change and disease outbreaks) of the ESA-listed wild-origin steelhead populations in Puget Sound;

d. these adverse genetic effects are significant, potentially long lasting, and could continue to adversely affect the productivity of ESA-listed Puget Sound winter-run steelhead populations for several to many generations (for 10 to 20 years or more);

e. many of the Chambers Creek adults that spawn with wild steelhead produce no returning adults, thus wasting the reproductive contribution those wild steelhead would have made to the wild population had they mated with other wild steelhead. These hatchery-wild matings will not contribute to the genetic introgression but will have a negative demographic impact on the numbers of wild steelhead returning to spawn in the wild;

f. the harm caused by these releases are a contributing factor to the decline and inability to recover of ESA-listed Puget Sound steelhead populations, some of which are nearing extirpation;

g. these releases of Chambers Creek steelhead—and the associated adverse genetic effects and reduced adaptive potential—likely cause significant harm to the entire Puget

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Sound steelhead Distinct Population Segment (DPS), which is already severely depressed, and its ability recover to a point where the protections of the ESA are no longer necessary;

h. these releases should therefore be discontinued or, at a minimum, significantly reduced and then closely monitored (e.g., for introgression and negative fitness effects on young and adult individuals) to prevent damage to the Puget Sound steelhead populations and to the ESA-listed Puget Sound steelhead DPS to which they belong;

THREATENED PUGET SOUND STEELHEAD

18. The Puget Sound steelhead DPS was listed as a "threatened" species under the ESA in 2007, and remains so listed;

19. Puget Sound wild steelhead numbers are approximately 1 to 4% of their historical abundance (Gayeski, et al. 2011; NMFS 2007). In NMFS' 2011 "status review" of this species conducted under the ESA, the agency stated that "[m]ost populations within the [Puget Sound steelhead] DPS are showing continued downward trends in estimated abundance, a few sharply so." The estimated mean population growth rates for all but a few populations within the Puget Sound steelhead DPS are declining—typically by -3 to -10% annually. In other words, the total number of wild-origin steelhead currently in Puget Sound is a small fraction of what it was historically and this number is continuing to decline;

20. The Puget Sound Steelhead Technical Recovery Team (PSSTRT), a multi-disciplinary science teams chaired by a staff person from NMFS' Northwest Fisheries Science Center, recently assessed the extirpation risk of twenty of the twenty-three component populations of the Puget Sound steelhead DPS (PSSTRT 2013). Twelve of the twenty were rated as a "high" extirpation risk ($\geq$ 70% probability in the next 20-100 years) and one additional

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one was rated as a "moderately high" extirpation risk (50% probability in the next 100 years). Only seven of the twenty populations, or 35%, were rated as a "low" risk of extirpation;

CHAMBERS CREEK STEELHEAD HATCHERY PROGRAMS IN PUGET SOUND

21. The Chambers Creek steelhead hatchery stock is originally derived from Chambers Creek in southern Puget Sound near Tacoma, Washington. However, the stock has diverged significantly from its wild counterparts through decades of strong artificial selection for specific traits (e.g., faster growth, smolting after only one year instead of two, and earlier return time), and adaptation to captivity. NMFS scientists provided the following description of this stock in an April 14, 2010, letter:

> The Chambers Creek winter-run steelhead stock was founded in the 1920s from the collection and spawning of native adult fish trapped in Chambers Creek, a south Puget Sound tributary. The propagation of Chambers Creek steelhead at this location occurred through 1945, when a new steelhead rearing program was initiated, leading to marked changes in this stock. In this new program, adult steelhead captured in Chambers Creek were transferred to the South Tacoma Hatchery in the upper watershed, where relatively warm water (12°C) was available to accelerate spawning maturation time. Additionally, the earliest maturing fish were selected for propagation. Continuous year-to-year use of these practices, combined with the warmer water and nutritional advances provided by newly developed dry diets, allowed the production of smolts in one year instead of two. The first hatcheries outside the Chambers Creek watershed to use this stock were located on the Green and Puyallup rivers and on Tokul Creek. The progeny of adult returns established through transplants of Chambers Creek hatchery fish to these and other Puget Sound hatchery release sites were transferred back to Chambers Creek when needed to offset egg take shortfalls, and were incorporated back into the winter-run steelhead population maintained at the site. However, as a standard practice, Chambers Creek was maintained as the sole annual source of eggs for other hatcheries.
>
> Chambers Creek Hatchery, originally a private trout hatchery, was purchased by the Washington Department of Game in 1972 and rebuilt. This hatchery was subsequently used to propagate and further develop the Chambers Creek winter-run steelhead stock and became the major source of winter-run steelhead broodstock for western Washington. Chambers Creek-derived winter-run steelhead have been propagated and released from most Puget Sound steelhead facilities, including Reiter Ponds, Tokul Creek, Wallace River, Dungeness,

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Bogachiel, Hurd Creek, Eells Springs, Kendall Creek, McKinnon Ponds, Samish, Lake Whatcom, Puyallup, Soos Creek, Voights Creek, Marblemount, Barnaby Slough, Grandy Creek, Fabors Ferry, Baker River, Davis Slough, Whitehorse Ponds, Arlington, and the Chambers Creek facilities. Most of the programs using this transplanted stock are still active.

The original goal of the Chambers Creek program was to produce an early returning adult steelhead that smolted after one year. By the mid 1970s, it was concluded that the advanced adult spawn timing selected to meet the yearling smolt objective created temporal separation in natural spawning areas between Chambers Creek hatchery winter-run and native late- winter-spawning steelhead, reducing the likelihood of interbreeding.

22. Chambers Creek-origin hatchery stock were explicitly excluded from the Puget Sound steelhead DPS protected under the ESA as a threatened species because of the extent to which this hatchery stock has diverge from its wild counterparts (NMFS 2007). NMFS has determined that the Chambers Creek hatchery steelhead have no role in the recovery of Puget Sound steelhead and, to the contrary, are likely contributing to the reduced productivity of the wild populations (NMFS 2007);

23. According to WDFW's HGMPs, the current Chambers Creek steelhead hatchery programs release hatchery fish in the numbers and locations described in the table below:

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Chambers Creek Steelhead Hatchery Program	Targeted Annual Release Number	Release Sites
Nooksack River Program	150,000	Kendall Creek, Nooksack River
Skagit River Program	230,000	Cascade River
Stillaguamish River Program	140,000	Whitehorse Spring Creek, Stillaguamish River
Duwamish/ Green River Program	70,000	Soos Creek, Icy Creek, Green River
Snohomish River Program	150,000	Tokul Creek, Snohomish River
	20,000	Wallace River, Snohomish River
	160,000	Reiter Ponds, Skykomish River, Snohomish River
Dungeness River Program	10,000	Dungeness River
Total Release	**930,000**	

OPINIONS ON CHAMBERS CREEK STEELHEAD PROGRAMS IN PUGET SOUND

24. Hatchery domestication results from a process analogous to natural selection, but occurring under unnatural conditions—the individual fish that are "selected" are those better adapted to live in unnatural conditions (high density, no predators, no disease or different disease, unnatural food, artificial spawning). The process results in loss of the ability to avoid predation, loss of disease resistance, loss of ability to forage and spawn efficiently, etc. This artificial selection pressure is strong; it results in rapid adaptation to captivity with loss of the ability to survive and reproduce effectively in the wild (Allendorf et al. 2013). The genes underlying these maladaptive traits will likely become fixed (or increase to high frequency) in hatcheries (even after only a few months of differential survival of embryos to smolts). These domestication effects occur even when the hatchery fish are derived from the nearby local wild

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population and the hatchery operations regularly incorporate local wild fish into the hatchery broodstock—which is not the case with Chamber Creek hatchery steelhead, which have been strongly segregated (isolated) from wild fish and highly domesticated over a period of decades;

25. One of the few studies to actually document the relative reproductive success of Chambers Creek hatchery steelhead spawning among themselves in the wild was conducted in Forks Creek, in Willipa Bay on Washington's west coast. This study, McLean et al (2003), showed that wild-spawning Chambers Creek hatchery steelhead had between 2.3% and 11.0% as many returning adult offspring per parent as wild steelhead;

26. Maladaptive genes from the hatchery fish will likely be transmitted to wild fish and thereby reduce the fitness of wild fish if the hatchery fish are allowed to spawn in the wild, as will occur when returning hatchery-produced adults stray onto the spawning grounds of local wild populations. Such straying has been documented as having occurred regularly in the past and is inevitable given the large number of smolts that WDFW releases. The negative fitness effects of hatchery fish derived from local natural populations on those same natural populations are widely documented in the scientific literature (e.g., Araki et al., 2007a,b, Araki et al. 2009, Christie et al. 2011, Christie et al. 2012, Normandeau et al. 2009; Theriault et al. 2011; Grant 2011; Lorenz et al. 2012). These negative effects will be worse in the case of non-local, domesticated hatchery stocks such as the Chambers Creek stock. Introgression of wild steelhead by Chambers Creek hatchery steelhead likely results in many hybridized individuals that fail to survive to reproduce, thereby wasting the genetic resources of the wild parent;

27. The Hatchery Scientific Review Group (HSRG) categorizes hatchery stocks and associated hatchery programs like Chambers Creek as "segregated" stocks and programs—in contrast to "integrated" stocks and programs in which the hatchery stock is founded from and

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regularly includes local wild fish as broodstock and may be intended to assist in the rebuilding of wild populations. The HSRG has established very conservative guidelines for managing segregated programs due to concerns related to genetic introgression. These guidelines call for limiting the maximum proportion of fish present on the natural spawning grounds that are of segregated-hatchery origin ("pHOS" or "percentage of hatchery-origin spawners") to less than 5%. It is my opinion that even this level of potential interbreeding between Chambers Creek hatchery and wild steelhead may be too high to limit or minimize negative fitness effects;

28. The 5% pHOS guideline nonetheless represents a numerical standard that is likely to be exceeded by a considerable margin by the number of Chambers Creek hatchery smolts that WDFW releases as described in the First Declaration of Dr. Jack Stanford (Stanford Declaration);

29. As noted, the McLean study (McLean et al. 2003, 2004) showed that the Chambers Creek fish returned between 2.5% and 11% the number of adults produced by wild steelhead. Chambers Creek hatchery fish spawning with wild steelhead would be expected to have fitness intermediate between these, but in view of the intense domestication and demonstrated low fitness of Chambers Creek fish this intermediate level is likely to be less than one-half (50%) that of wild fish. Consequently, interbreeding between local wild steelhead and stray Chambers Creek hatchery steelhead throughout Puget Sound can be expected to reduce the fitness of wild steelhead that spawn with Chambers Creek hatchery steelhead by at least one-half. This imposes a severe genetically-based fitness burden on already depressed local populations of wild Puget Sound steelhead. The negative effects from hatchery gene introgression likely persists for many years (generations), however few empirical data exist on duration of effects;

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30. A wild winter-run steelhead supplementation program in the Hood River, Oregon was started in 1991 and has continued to the present. Conditions there allow the program to control the collection of adults for broodstock and the numbers of hatchery-produced steelhead that spawn naturally. It is important to note that such ideal conditions (bringing in new wild parents into the hatchery to reduce adaptation to captivity) are not present for most steelhead programs. The success of the Hood River program has been studied intensively by Dr. Michael Blouin and colleagues at Oregon State University, with key results reported in numerous peer-reviewed scientific publications (including Araki et al. 2007a,b, Araki et al. 2009, Christie et al. PNAS 2011, and Christie et al. Heredity 2012). Araki et al. have shown that on average first-generation hatchery fish produced from native wild broodstock have only 60% to 80% of the reproductive success in the wild compared to the native wild fish themselves. Araki et al. have also shown that when second-generation supplementation hatchery fish (i.e., the offspring of wild-spawning first-generation hatchery fish) spawn in the wild, they also produce fewer surviving adult offspring than pure wild fish (W x W). The fact that the loss of fitness is a genetic effect (i.e., has a genetic basis), and was not an effect of the hatchery rearing environment, was demonstrated. It is likely Chambers Creek introgression would cause even more severe reduction in fitness in wild fish than was observed in Hood River, because Chambers fish have been more strongly selected to change crucial life history traits and for adapted to captivity;

31. In another example, steelhead from the Skagit showed high introgression from Chambers Creek hatchery fish (up to 80% of the naturally produced fish were hatchery hybrids). This demonstrated that segregation of hatchery from wild fish was unsuccessful. Furthermore, reproductive success was lower for the hybrid (early spawning) fish (Seamons et al. 2012).

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Fitness reduction is expected to be more severe following introgression (hybridization) with segregated (highly selected) fish like Chambers Creek than from less selected fish like, for example, Hood River fish (Baskett and Waples 2013). As noted, the McLean et al. study (2003) showed that wild-spawning Chambers Creek hatchery steelhead had only between 2.3% and 11.0% as many returning adult offspring per parent as wild steelhead;

32. In addition to the genetic impacts from the interbreeding of Chambers Creek hatchery with wild steelhead on the natural spawning grounds, there is a separate demographic effect on the number of wild spawners that occurs due to the lower fitness of wild fish that interbreed with hatchery instead of with other members of the wild population: each generation fewer pure wild adult fish will return because fewer wild fish bred with one another than in the previous generation. If any of the progeny of the interbreeding of hatchery and wild fish do survive to return, the total returning adult population will still be smaller than if only wild fish bred with one another because each hatchery-wild mating will produce fewer returning adults than a wild-wild mating would have. If wild-hatchery matings produce no returning adults the returning adult population will be made up of only the offspring of wild-wild matings, but the total, purely wild, population will be lower in number still. Consequently, even in the extreme case where wild-hatchery matings result in no gene flow from hatchery spawners to the local wild population, the lower fitness of wild-hatchery matings in the preceding generation still produces a serious negative, though purely demographic, impact on local wild populations. This effect thus constitutes an additional threat to the viability of local wild Puget Sound steelhead populations, and thereby to the viability of the entire Puget Sound steelhead DPS;

33. Introgression of wild steelhead by Chambers Creek hatchery steelhead is likely to result in hybridized individuals that either fail to survive to reproduce—thereby wasting the

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genetic resources of the wild parent—or produce offspring whose reproductive fitness is lower than pure wild fish, resulting in offspring that contribute to a gradual lowering of the average fitness of the wild population. This type of introgression might not manifest itself as a hybrid swarm (at least initially) whereby most individuals in the wild/hybrid/hatchery population contains a mixture of genetic material from the wild and hatchery populations. Rather, introgression will likely initially result in a small to moderate number of individuals with a proportion of hatchery genes accompanied by the gradual depression of the fitness of the surviving members of the wild population;

34. Detection and quantification of the extent of introgression will depend on several factors, including: the frequency of cross-breeding, the manner by which genetic samples from the wild population are obtained, the type and genome position of genetic markers employed, and the number of marker loci employed. It is now becoming standard procedure to genotype 100 to 1000 population-diagnostic or informative markers to detect introgression (e.g., Hohenlohe et al. 2012 and 2013; Amish et al. 2012). The Chambers Creek tests for introgression should include tens of population-informative markers, rather than a dozen markers of relatively low population-diagnostic informativeness (e.g., low genetic differentiation, i.e. *F*st). Use of many dozens of such (informative) DNA markers is the only way to ensure detection and reliable quantification of admixture, especially in cases where only a small proportion of the genome from the maladapted population (e.g., hatchery fish) is likely to introgress rapidly (e.g., Hohenlohe et al. 2013);

35. A particular concern with Chambers Creek introgression is the likelihood that a majority of progeny from matings between Chamber Creek and wild steelhead may die at young juvenile ages before they can be included in genetic samples. This produces a deleterious

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demographic impact on wild populations distinct from genetic impacts; however, loss of progeny of hatchery-wild matings at young juvenile ages will considerably complicate the detection of this interbreeding by genetic methods. It is very important that a sampling study design aimed at detecting the genetic signals of interbreeding between Chambers Creek hatchery steelhead and wild steelhead include acquiring samples of fertilized eggs deposited in spawning nests ("redds"), or at least of juveniles during the first month or two following emergence of fry from the gravel. Reliable detection of cross-breeding and assessment of negative effects of introgression requires sampling many tens or 100s of redds and/or fry and genotyping with dozens of DNA markers;

36. The recently published Saltstall-Kennedy funded Skagit River study, released April11, 2013, provides considerable data and information regarding the complexity of the issues involved in acquiring and analyzing samples in order to identify and quantify the extent of Chambers Creek introgression of wild steelhead. Two points are worth noting about the Skagit study in this regard. First, the introgression analyses were peer reviewed by NMFS Conservation Biology Division geneticist and chair of the Puget Sound Steelhead Technical Recovery Team, Dr. Jeff Hard. Second, the Skagit River has extensive high quality steelhead spawning and rearing habitat so that native wild steelhead are not confined to a few miles of river where returning adults are considerably outnumbered by returning hatchery adults, as was the case in the lower Elwha River until 2012. Despite this and despite evidence of high homing of hatchery adults to the Marblemount Hatchery (as evidenced by the genetic composition of adults returning to the hatchery facility), the Skagit study documented considerable evidence of Chambers Creek hatchery steelhead spawning in the wild both with themselves and with wild Skagit steelhead. A

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critical element of the Skagit study in this respect was extensive planned sampling of juveniles early in their first year of life;

37. The recently completed Final Administrative Report (Beamer 2013) relating to the above Skagit River study concluded that "The study results indicate that the segregated hatchery steelhead program currently operating in the Skagit River basin may be negatively impacting the Skagit wild steelhead population." The report also provides recommendations such as: "1. Discontinue the segregated hatchery steelhead program in the Skagit River basin and monitor the results for approximately eight years. Expected responses of this recommendation are three-fold: a) elimination of hatchery and wild steelhead competition at all life stages, b) a rapid reduction of hybridization rates between hatchery and wild steelhead, and c) an increase in survival of wild steelhead;"

38. The evidence and considerations provided above is persuasive, in my opinion, that any amount of interbreeding in the wild between Chambers Creek hatchery steelhead and wild steelhead will only have a harmful impact on the current and near-term population size of local wild Puget Sound steelhead populations and on the longer term fitness and adaptive capacity of wild populations. Such impacts can only further threaten the viability and recovery potential of the Puget Sound steelhead DPS. The DPS would best be protected from this threat by the termination of all Chambers Creek hatchery releases into Puget Sound rivers. Any level of interbreeding of Chambers Creek hatchery steelhead with wild steelhead will impose a harm on the local wild population that poses a threat to the viability and adaptive potential of that population. Short of complete termination of all Chambers Creek hatchery programs, reducing the threat to a low level is essential and this will require reducing the number of Chambers Creek hatchery steelhead smolts that WDFW releases to a considerably smaller fraction of that number;

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OPINIONS ON SPECIFIC CHAMBERS CREEK HATCHERY PROGRAMS

A. The Dungeness River Program.

39. As explained in the Stanford Declaration, the data provided in Tables 2.2.2.7 and 3.3.1.1 of the Dungeness River HGMP provide reasonable evidence that the release of 10,000 Chambers Creek-origin hatchery steelhead smolts in the Dungeness River watershed is likely to result in adult hatchery steelhead straying onto the spawning grounds of wild Dungeness steelhead in great enough numbers to equal or exceed a pHOS level of 5%—the upper limit recommended by the HSRG for segregated hatchery programs and the upper limit allowed under WDFW's Washington State Steelhead Management Plan (SSMP). I consider hatchery genetic introgression levels lower than 5% and even as low as the ~2% management limit of the SSMP to likely pose significant harm to the fitness of wild steelhead populations. This harm likely results from the cumulatively effects of the 5% (or 2%) annual introgression adding up to much higher long-term (multi-year) introgression, which could reach far greater than 5% over several years. Because hatchery smolt releases have occurred for many years, it is likely that the proportion of hatchery-introgressed fish is far higher than even 20% in many river populations.

40. The Dungeness River HGMP acknowledges that no reliable monitoring is conducted to quantify the number of hatchery winter-run steelhead spawners in the Dungeness (page 18), nor the numbers of wild steelhead escaping to spawn (page 17). Contrary to unsubstantiated assertions in the HGMP (for example, at the end of section 2.2.2 on page 18), I find no reason to believe that pHOS is likely to be less than 5% "based on the number of hatchery steelhead smolts released annually, hatchery steelhead harvest rates, and the number of annual hatchery returns for the last 10 years." On the contrary, the Dungeness River HGMP acknowledges that hatchery "smolt-to-adult survival rates (SAR) are likely to be underestimated

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(page 2)", and Dr. Stanford has explained that a hatchery SAR only slightly greater than the estimate based on the most recent five years will produce enough additional returning hatchery adults to escape to the spawning grounds in excess of a pHOS of 5%;

41. Regarding actual levels of gene flow from hatchery steelhead to wild Dungeness River winter-run steelhead, the HGMP provides no hard data showing that recent levels of introgression are low or that there is any good reason to believe that they might be low. Rather, based on the data provided in the HGMP, it is my opinion that it is likely that the level of gene flow from hatchery to wild steelhead is significant and of a magnitude to cause harm to the wild Dungeness winter steelhead population given the number of annual hatchery smolt releases during the recent past and proposed for the future (10,000);

42. Based on the average number of hatchery smolts released in the past five years (Table 3.3.1.1) of over 8,000, approximately 90 or more hatchery adults are expected to return to the Dungeness River watershed in each of the next two or three years if the hatchery SAR is no greater than the average for the past five years, even if no smolts are released in 2014. This would be 60 above the proposed annual broodstock requirements and is considerably greater than the recent five-year average in-river harvest of 44 fish. There is, therefore, a very high probability that significant interbreeding between hatchery and wild adults will occur given the depressed condition of wild steelhead in the Dungeness as reflected in the low numbers of wild steelhead smolts reported in the Dungeness River HGMP (Table 2.2.2.7);

B. The Nooksack River Program.

43. The Nooksack River Program proposes to release 150,000 Chambers Creek-origin hatchery smolts annually. According to the information provided in Table 3.3.1.1 of the Nooksack River HGMP (page 26), the smolts from this program have a very low SAR (less than

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0.2% over the most recent five year period). But as for all of these HGMPs, the hatchery SAR estimates are likely to be under-estimates due to the inability to account for adults that return to the basin (Section 1.12, page 13) and are neither caught in fisheries nor return to the hatchery facility to be spawned, but instead stray onto the spawning grounds with wild Nooksack River winter-run steelhead. As explained in the Stanford Declaration, only a very small increase in the hatchery SAR estimated from the sum of in-river harvest plus hatchery escapement is required to result in a pHOS equal to or greater than the 5% upper management limit. Even if the twelve year average hatchery SAR of 0.48 is used (producing an expected annual hatchery adult return of 720 (page 13), a true SAR of 0.54% would result in a pHOS of 5%, assuming that all 720 were either caught in in-river fisheries or returned to the hatchery;

44. It is my opinion that it is highly likely that pHOS has in the recent past equaled or exceeded the 5% threshold, and will do so in the future if 150,000 hatchery smolts are released annually as proposed in the HGMP. This level of presence of adult hatchery-origin steelhead on the spawning grounds will result in harmful genetic (introgression) and demographic impacts to the wild Nooksack winter-run steelhead population;

45. Pages 17 – 22 of the Nooksack River HGMP provide a summary of WDFW's analyses that purport to demonstrate that pHOS is less than 5% and that introgression of hatchery steelhead genes from the Kendall Creek program to wild Nooksack winter-run steelhead is less than 2%. Two methods of analyses that yield these results are referred to: "Method 1" based on genetic analyses of adult and juvenile steelhead samples of Nooksack winter-run steelhead, and "Method 2" based on estimates of stray rates from on- and off-station hatchery smolt releases. The descriptions of both methods are cryptic and not as clear as is required to fully evaluate either their plausibility or accuracy;

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46. Method 1 is explained in the Draft document by Ken Warheit of the WDFW genetic laboratory, dated March 17, 2014. The method is complex and novel, not fully explained in the Draft document, and requires independent scientific peer review to be accepted as credible. This has not yet been done, so both the method and specific conclusion drawn from it must be taken provisionally with a grain of salt. Importantly, the statements regarding levels of pHOS in the Nooksack River based on Method 1, that are made in the Nooksack River HGMP (pages 18-19, summarized in Table 2.2.2.5), are at odds with corresponding results in the Draft document (page 19 and Table 8f, page 47). Page 19 of the Draft states a "total effective" pHOS of 9% and introgression (gene flow) of 11% for mainstem Nooksack early winter-run adults. "Effective pHOS" is pHOS in previous generations that resulted in surviving introgressed (hatchery-wild hybrid) adult offspring, and is generally lower than the actual or nominal pHOS, which is the proportion of the actual number of hatchery-origin adults on the spawning grounds regardless of whether they breed with wild spawners or (if they do interbreed) regardless of whether they produce viable adult offspring. Table 2.2.2.7 of the Nooksack River HGMP however, asserts total pHOS of no more than 5% and gene flow of no more than 2%. For the reasons explained above and in the Stanford Declaration, I believe the larger figures from the Draft Report, are more likely to be correct, but in any case the contradictions provide little reason to give much credibility to either. On balance, it is my professional opinion that the annual smolt release level of 150,000 is likely to cause harm to the wild Nooksack winter-run steelhead population from both adverse genetic and demographic effects;

47. Method 2 is apparently explained in a document by A. Hoffman (2014) titled "Estimates of gene flow for Puget Sound hatchery steelhead programs" cited on page 19 of the HGMP and listed among the cited docuemtns in Section 13 of the HGMP (page 47). However,

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no copy of the report was provided me to review and it is my understanding that Plaintiff has not been provided with this key document. Method 2 estimates "effective pHOS" by estimating the relative survival of hatchery-origin spawners (hos) in the wild (number of hos times relative survival of hos) and then dividing this number by the sum of this number and the number of natural origin (wild) spawners. It is, therefore, an estimate of pHOS (the number of hatchery-origin adults on the spawning grounds relative to the total number of hatchery-origin plus wild-origin spawners) in the generation preceding the generation from which the actual DNA samples were obtained. Relative Survival hos is taken to be equal to 0.11 (11% the survival of wild spawners), following the value estimated by the HSRG (Nooksack River HGMP page 19). While this value is reasonable, it does not account for the fate of the progeny of hatchery-wild matings and will thus under-estimate the number of hatchery-origin spawners on the spawning grounds in previous generations. In order to estimate the pHOS in the generation preceding the generation from which DNA samples were obtained, it is necessary to estimate both the hatchery-origin spawners present on the spawning grounds in the preceding generation that spawned among themselves and those that spawned with wild spawners. As far as I am able to determine from the description of Method 2 in the HGMP, this is not what was done, and therefore, even if the method is otherwise valid and based upon an adequate number of samples obtained in a statistically valid fashion, the results reported will considerably under-estimate pHOS in the preceding generation. The results from Method 2 are reported in Table 2.2.2.8 (page 22) and report very low levels of gene flow (less than one-half of one percent (<0.5%) in all cases. There is, however, no explicit numerical example showing how any of the results for any one of the cases are actually achieved and I could find no way to confirm or disprove the numbers listed in the Table. However, the numbers for gene flow in Table 2.2.2.8 are

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unconvincing (because they are too low) given the more credible estimation of the likely numbers of stray hatchery adults derived by Dr. Stanford using conservative estimates of hatchery SAR and the recent estimates of the number of wild spawners. Moreover, even were the low gene flow numbers reported in Table 2.2.2.8 accepted, they support the point made earlier that hatchery fish that mate with wild adults but produce no surviving adult progeny impose a significant demographic harm to the wild population by reducing the total numbers of wild adults that would return to spawn in the wild if their parents had not spawned with hatchery fish. The "effective pHOS" statistic used in the Nooksack River HGMP ignores this impact;

48. I conclude that the proposed release of 150,000 Chambers Creek-origin hatchery smolts will have a high probability of harming wild Nooksack winter-run steelhead and impairing their ability to rebuild and contribute to the recovery of the Puget Sound steelhead DPS;

49. Based on the average number of hatchery smolts released in each of the past five years (Table 3.3.1.1) of nearly 150,000, as many as 900 or more hatchery adults may be expected to return to the Nooksack River watershed in each of the next two or three years if the hatchery SAR is no greater than the average for the past five, even if no smolts are released in 2014. This is 784 more than the proposed annual broodstock requirement and is considerably greater than the recent five-year average in-river sport harvest of less than 100 fish. There is, therefore, a very high probability that significant interbreeding between hatchery and wild adults will occur in the next two or three years;

C. The Skagit River Program.

50. Table 3.3.1.1 of the Skagit River HGMP (page 36) shows that considerable numbers of Chambers Creek hatchery smolts have been released into the Skagit River watershed.

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For example, the average annual release for releases corresponding to adult return years 2001/2002 to 2008/09 is 498,000. If wild Skagit winter steelhead smolts had an average SAR of 1% during this period (two to three times higher than the SAR of Skagit hatchery smolts during this period), the average number of wild smolts would be 550,000. Under this scenario, hatchery smolts would have been nearly as numerous as wild smolts, making competitive interactions highly likely to the detriment of wild smolts;

51. Equally important, even with the significantly lower SAR assumed for this comparison, it requires only a very minimal increase in the hatchery smolt SAR to have produced enough additional returning hatchery adults to equal or exceed the 5% pHOS level, as described in the Stanford Declaration for the recent five year averages;

52. In my opinion, it is very likely that these large hatchery smolt releases result in matings between wild and hatchery steelhead with harmful effects to wild Skagit River winter-run steelhead. These harmful effects include reduced abundance of wild adult steelhead due to the failure of the offspring of many of the hatchery-wild matings to survive to adulthood, and lowered reproductive performance of the progeny of hatchery-wild matings that did survive to return to reproduce in the wild. These latter would have resulted in the introgression of hatchery genes into the wild population. These individuals, progeny of hatchery-wild matings, would not have missing adipose fins like their hatchery parents, but rather would appear to be wild fish (indeed, they would be "natural-origin" fish). Some of these individuals would likely have been included in adult samples used to estimate the genetic composition of wild Skagit steelhead, and this would increase the odds that introgressed individuals would be very difficult to distinguish from true wild adults by the recent genetic tests described in the Warheit report;

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53. In addition, this recent introgression, as well as introgression that occurred further in the past as a result of very large hatchery smolts releases in the 1980s and 1990s, (Approximately 5.3 million between 1979 and 1994 (NMFS 2007, Appendix D, Table D-1)) would have lowered the productivity of the wild population. Thus, the current productive capacity of the wild Skagit steelhead population is in part very likely a legacy of the past twenty or thirty years of hatchery smolt plants (among other contributing factors). This impaired productivity makes it even more critical that opportunities for introgression of Chambers Creek hatchery genes into the Skagit and other Puget Sound wild steelhead populations be eliminated in order to maximize the opportunity for wild steelhead populations to begin to recover their productive capacity in the context of current and future environmental selective regimes (natural selection in the wild);

54. As I noted in my comments on the Nooksack River HGMP, I am skeptical that the low gene flow estimates for Skagit River steelhead populations reported in the Skagit River HGMP on the basis of the analyses described in the Warheit report. As for the Nooksack River HGMP, it needs to be emphasized that the Warheit report is a draft and employs a method that is novel and has yet to undergo independent scientific peer review. I cannot explain or account for the extremely low levels of gene flow reported for the Skagit on pages 22-23 based on this method, given the recent data on numbers of hatchery and wild smolts and adults in the past decade. I would have the same concerns with "Method 2" as I have described for the Nooksack River HGMP. However, I note that the entire section of the Skagit HGMP devoted to Method 2 (pages 24-31) is struck-through, further indicating the provisional and draft status of this entire section;

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55. Despite the concerns with the methods based on the Warheit draft, I note that high gene flow (introgression) is nonetheless reported for the Cascade River (17%, Warheit report page 18). Also, a level of 2% is reported for Finney Creek in the report. It is my professional opinion that each of these is a cause for concern regarding the fitness and adaptability of the affected wild populations. This introgression will likely reduce individual fitness (survival and reproductive success) as well as population performance (growth rate, adaptive potential, and thus abundance). Some of the fitness reductions and population declines would likely persist for many years (generations);

56. Based on the average number of hatchery smolts released in each of the past five years (Table 3.3.1.1) of over 333,000, approximately 2000 or more hatchery adults may be expected to return to the Skagit in each of the next two or three years if the hatchery SAR is 0.5% or greater, even if no smolts are released in 2014. This would be 1800 above the proposed annual broodstock requirements and is considerably greater than the recent five-year average in-river harvest of less than 1000 fish. There is, therefore, a very high probability that significant interbreeding between hatchery and wild adults will occur in the next two or three years;

D. Concerns Regarding the Samish River Steelhead Population.

57. An important issue not directly addressed by either the Nooksack River HGMP or the Skagit River HGMP is the "effective pHOS" of 8% and the introgression of Chambers Creek-origin hatchery genes of 17% in the wild Samish River winter steelhead population, reported in the Warheit report;

58. The Samish River enters Puget Sound between the Nooksack and Skagit Rivers, and thus likely receives stray Chambers Creek steelhead from either or both the Nooksack River Program and the Skagit River Program. The Warheit report notes that there is no steelhead

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hatchery program on the Samish River but that hatchery plants occurred from the Whatcom Hatchery (part of the Nooksack River program) in 2005, 2006, and 2007. The tissue samples from the Samish on which these results were based were from two adult collections of 42 and 46 fish, respectively, in 2008 and 2012. It is unlikely that these results result entirely from the hatchery smolt releases in 2005-2007. It is more likely, in my opinion, to reflect introgression from recent strays from either of the two hatcheries or a combination of recent strays from the hatcheries and progeny from successful interbreeding between wild Samish steelhead and returning hatchery adults from one or more years of the smolt releases in 2005-2007;

59. The Samish River is likely to be an important local wild winter steelhead population for the recovery of Puget Sound steelhead and illustrates the importance of further reducing or eliminating entirely hatchery smolt releases in nearby river basins to protect wild steelhead from the risks of interbreeding with stray hatchery steelhead (direct genetic introgression and reduced wild abundance due to the low rates of survival and reproduction of progeny from wild-hatchery matings);

E. The Stillaguamish River Program.

60. The Stillaguamish River HGMP contains no estimates of pHOS, "effective pHOS", or gene flow for Stillaguamish wild winter-run steelhead based on data or techniques described in the Warheit report. The Stanford Declaration makes it clear that the proposed release of 140,000 hatchery smolts is likely to considerably exceed the annual number of wild winter-run steelhead smolts given the severely depressed condition of the wild adult steelhead population. The recent five-year average spawning escapement of wild winter-run steelhead is 300, which is far lower than the expected abundance of the basin's wild steelhead population if

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the wild SAR today were a meager 1% of 1912 (PSSTRT 2013; Whitehorse Ponds HGMP, Table 2.2.2.2, page 15);

61. As shown by Dr. Stanford, the annual number of wild smolts during the past five years has most likely ranged between 30,000 and 60,000. This is 20% to 40% the number of hatchery smolts proposed to be released according to the HGMP. Such a large absolute and relative number of hatchery smolts compared to the depressed wild smolt production is certain to result in harmful interactions between wild and hatchery adults on the spawning grounds, in addition to other adverse competitive interactions at younger ages;

62. Given the legacy of past hatchery smolt releases and its likely impact on the productivity of wild Stillaguamish steelhead, as explained in my comments on the Skagit River Hatchery HGMP, it will, in my opinion, be very difficult or impossible for the wild Stillaguamish winter steelhead population to recover productivity and rebuild under the competitive load that has been and will continue to be imposed upon it by the number of hatchery smolts proposed to be released by the Stillaguamish River HGMP;

63. The Puget Sound TRT has estimated the potential adult abundance of Stillaguamish steelhead at 1912 if wild SAR is 1%, a very low level for a healthy steelhead population. This would require a wild smolt production of 191,000, greater than the sum of proposed Chambers Creek hatchery smolt releases (140,000) and recent estimated wild smolt production if wild SAR were 1% (30,000);

64. It is very likely, in my opinion, that wild Stillaguamish winter steelhead cannot recover without the significant reduction or elimination of the Stillaguamish River hatchery program;

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65. Finally, based on the average number of hatchery smolts released in the past five years (Table 3.3.1.1) of 132,000, between 400 and 1000 hatchery adults are expected to return to the Stillaguamish River in each of the next two or three years depending on a range of SAR values below 1%, even if no smolts are released in 2014. This would be 280 to 880 above the proposed annual broodstock requirements and is considerably greater than the recent five-year average in-river harvest of less than 250 fish. There is, therefore, a very high probability that significant interbreeding between hatchery and wild adults will occur during the next two or three years. As for the other programs mentioned above, introgression will likely reduce wild steelhead abundance and adaptive potential due to the low rates of survival and reproduction of progeny from wild-hatchery matings;

F. Snohomish River Program.

66. As explained in the Stanford Declaration, the recent five-year average return of Snohomish River basin wild winter-run steelhead is 2123, considerably below the PSSTRT's estimated Low Abundance Threshold of 4332;

67. Chambers Creek hatchery-origin steelhead released from hatchery facilities in the Snohomish Basin have the highest SAR's of all hatchery programs described in the six HGMPs. The 12-year average hatchery SAR from 2000/01 to 2011/12 is 1.29%; the recent five-year average is 0.93%;

68. If the wild SAR over the past five years is half as great as the hatchery SAR (1.4%), the recent five-year average wild smolt production would be 152,000. This is less than one-half the number of Chambers Creek-origin hatchery smolts proposed to be released. Further, the proposed release of 330,000 smolts is 79% the average number of smolts released

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each of the past twelve years. This is not a very significant reduction in view of the current status of the wild population;

69. The Snohomish River HGMP estimates significantly high levels of pHOS and introgression, especially for the Snoqualmie River population, based on the two methods employed in the Nooksack River HGMP and the Skagit River HGMP and about which I have already commented. The Warheit report on which the estimates of pHOS and gene flow are based notes that the genetic analyses of the tissue samples from Snohomish Basin steelhead were the most complicated of the Puget Sound steelhead samples (provisionally) analyzed. Given the uncertainties of these analyses and the concerns with the methods that I have already expressed, I believe the estimates of pHOS and introgression are more likely to under-estimate than to over-estimate either or both pHOS or gene flow;

70. In any case, in my opinion the proposed release numbers are far greater than is advisable in view of the depressed total abundance of wild winter steelhead in the Snohomish Basin, the large number of tributaries that likely contain distinct subpopulations of wild steelhead and the resulting complex population structure in the basin that has been poorly sampled to date (for example, the Pilchuck River wild winter adult steelhead population was only sampled in 2012);

71. Based on the average number of hatchery smolts released in the past five years of 425,000 (Table 3.3.1.1), 4000 or more hatchery adults are expected to return to the Snohomish River system in each of the next two or three years given estimated SAR values in recent years just below 1%, even if no smolts are released in 2014. This would be more than 3800 above the proposed annual broodstock requirement and is considerably greater than the recent five-year average in-river harvest of 3100 fish. There is, therefore, a high probability that significant and

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harmful interbreeding between hatchery and wild adults will occur during the next two to three years;

G. The Duwamish/Green River Program.

72. As discussed with other programs, the number of hatchery steelhead smolts released in the Green River in the majority of the past 12 years (reported in Table 3.3.1.1 of the Duwamish/Green River HGMP, page 26) have likely been as great as or greater than the number of wild smolts produced. As described in the Stanford Declaration, this makes it highly likely that returning hatchery adults escape in-river fisheries (and fail to return to the hatchery) numbers that exceed the 5% pHOS. The estimates of pHOS and gene flow reported in 2.2.2 of the Duwamish/Green River HGMP (pages 18 – 22), based on Methods 1 and 2 that I have already discussed, are consistent with this expectation;

73. Table 2.2.2.8 (page 22) of the Duwamish/Green River HGMP, based on Method 2, indicates several years with estimated levels of gene flow in excess of 20%. Thus, it is reasonable to believe that the fitness (and productivity) of the wild Green River winter-run steelhead population has been depressed by this introgression (as well as similar levels of introgression in the more distant past when hatchery smolt releases were as high or higher (over 3.4 million between 1982 and 2004, NMFS 2007, Appendix D, Table D-1). This makes most any level of introgression or demographic depression from hatchery-wild interactions on the spawning grounds a threat to the viability and recovery potential of the wild Green River steelhead population;

74. As explained in the Stanford Declaration, the recent five-year average wild steelhead spawning escapement in the Green River (Table 2.2.2.4, pages 17-18) is 614. A pHOS of 5% would be achieved if 31 hatchery-origin adult steelhead were present on the spawning

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grounds with 614 wild steelhead. I agree with Dr. Stanford's reasoning that it is very likely that at least this number of stray adult hatchery steelhead will be produced by the proposed smolt release level of 70,000;

75. It is my professional opinion that such a level of straying will result in the demographic depression of the wild Green River winter steelhead population through interbreeding of wild and hatchery adults that result in no (or very few) returning adult offspring and the depression of the fitness (productivity) of the wild population through the introgression of maladapted genes from domesticated Chambers Creek-origin hatchery steelhead into the wild population. As explained previously, this harmful genetic effect will occur even if the level of pHOS is below 5% and the nominal level of gene flow in any one year is less than 2%;

76. Based on the average number of hatchery smolts released in the past five years of 229,000 (Table 3.3.1.1), 1100 or more hatchery adults are expected to return to the Green River in each of the next two or three years given estimated SAR values in recent years of 0.5%, even if no smolts are released in 2014. This would be more than 1020 above the proposed annual broodstock requirement and is considerably greater than the recent five-year average in-river harvest of 411 fish. There is, therefore, a very high probability that significant and harmful interbreeding between hatchery and wild adults will occur during the next two or three years. Finally, as for other programs, some of the harmful effects of introgression on fitness of wild populations will likely persist for many years;

CONCLUSION

77. In sum, it is my professional opinion that WDFW's Chambers Creek steelhead hatchery programs in Puget Sound harm threatened Puget Sound steelhead and their ability to recover. The Chambers Creek steelhead (and their offspring) most likely have severely reduced

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fitness compared to wild steelhead due to decades of domestication and strong selection causing genetic adaptation to a hatchery environment. Some adult Chambers Creek steelhead most likely cross-breed with wild steelhead, and it is highly likely that the resultant offspring have reduced fitness (i.e., survival and reproduction) in the wild. Maladapted genes introduced into the wild steelhead population will likely persist for many generations even after the returns of hatchery fish have ceased, thereby causing long-lasting harm to the populations. It is therefore my opinion that these Chambers Creek steelhead hatchery programs are most likely causing significant harm to wild ESA-listed steelhead populations and to the Puget Sound steelhead DPS to which they belong, and to the ability of this species to recover;

I declare under penalty of perjury under the laws of the United States of America that the foregoing is true and correct.

Executed this 15th day of April, 2014.

Gordon Luikart

Gordon Luikart, Associate Professor
Flathead Lake Biological Station, University of Montana

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EXHIBIT 1

Curriculum Vitae

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January 2014

CURRENT APPOINTMENTS:
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Visiting Senior Scientist, Center for Investigation of Biodiversity and Genetic Resources (CIBIO), University of Porto, Portugal, 4485-661 Vairão, Portugal. http://cibio.up.pt/

BIRTH/FAMILY: Born 30 October, 1964; Sioux City, Iowa, USA; American citizen; France residency card; married, two children

EDUCATION: Ph.D., University of Montana, 1997, Organismal Biology and Ecology
Supervisor: Dr. Fred Allendorf; Field supervisor: Dr. J. T. Hogg
M.S., University of Montana, 1992, Zoology
B.S., Iowa State University, 1988, General Biology, minor in Animal Ecology

POSTDOCTORAL:
Research Fellow, Population Genetics and Demographic History, CNRS, France, 1999-2000.
NSF-NATO Postdoc Fellowship, Conservation Biology and Population Genetics, 1998-1999
Advisors: P. Taberlet (Université Joseph Fourier, France), J.-M. Cornuet (Institue Nationale Recherche Agriculture, France).
European Postdoc Fellow, Conservation & Evolutionary Genetics, Université Joseph Fourier, 1997-1998.

RESEARCH INTERESTS: Conservation Biology, Ecology, Evolution, Population/Landscape Genomics

EMPLOYMENT:
2010-current, Associate Professor, Flathead Lake Biological Station, University of Montana, USA
2005-2010, Research Associate Professor, Organismal Biology and Ecology, University of Montana, USA
2005-current, Visiting Senior Research Scientist, Centro de Investigacio em Biodiversidade e Recoursos Geneticos (CIBIO), University of Porto, Vairão, Portugal
2003-2005, Faculty Affiliate, University of Montana, USA
2004-2005, Research Scientist, Montana Conservation Science Institute (MOCSI), USA
2001-2005, Research Scientist (CR1), CNRS (Centre National Recherche Scientifique), France (Officially on leave without pay until 2015)
2000-2001, CNRS, Research Fellow, Statistical and Population Genetics, France
1991-1992, Teaching Assistantships, Biological Station, U. of Montana (Aquatic Botany, Mammal Ecology)
1989-1995, Teaching Assistantships, U. of Montana (Genetics & Evolution, Conservation Genetics, Mammalogy, Ecology, Anatomy & Physiology),
1987, Research and Teaching Assistant, Sumilon University, Philippines (SCUBA diving & Marine Biology)
1986, Field Research Assistant, Virginia Polytech Institute (trapping & banding passerine birds)
1985-1986, Iowa Department of Natural Resources (gill-netting, radio-telemetry of fish, grouse, & otters)

ACADEMIC HONORS:
Adjunct Professor (can supervise grad students), Wildlife Program, University of Montana, 2010-current
Bronze medal, a top scientist in France CNRS (Centre Nationale de la Recherche Scientifique), 2004-2005
Doctoral Research Fellowship, University of Montana, 1996
Fulbright Fellow, La Trobe Univ., Melbourne, Australia, 1994-95 (Genetics of Endangered Marsupials)
Scholarship: top 5% of graduate students in research at The University of Montana, 1991, 1994
Phi Beta Kappa National Honors Society Award (top 5% of liberal arts students in USA), 1988

PROFESSIONAL ACTIVITIES: 2001-2004, Journal editorial board member for *Conservation Biology*
2003-2006, Journal associate editor for *Molecular Ecology Resources*
2009-2011, Associate editor for *Journal of Heredity*
2010-curent, Member Swan Ecosystem Center Native Fish Committee

TEACHING: 2014-future, Conservation Genetics, 3 credits (advanced undergrads and graduate students)
2010-current, Conservation Ecology, 3 credits (advanced undergrads), field course
2007-2010, Genetic and Evolution, 3 credits (team taught, graduate students in NSF-IGERT)
2007-current, Population Genetics seminar, 1 credit (undergrad and grad students)
2006, 2010 Frontiers in Conservation Genetics, 2 credits (team taught)
2007-2008 Population Genetic data analysis, 2 credits (Univ. of Porto, grad students)

SOCIETIES (Last five years): American Fisheries Society
Ecological Society of America
Society for Conservation Biology
Society for the Study of Evolution
Wildlife Disease Association
Wildlife Society

BOOKS:

Allendorf, F.W. and **G. Luikart**. 2007. *Conservation and the Genetics of Populations*. Wiley-Blackwell. Pp. 642.

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*Kardos, M., **G. Luikart**, F.W. Allendorf. Measuring individual inbreeding in the age of genomics: marker-based measures are better than pedigrees. Accepted pending revisions.

*Hand B.K., S. Chen, D. Raiford, W. Lowe, **G. Luikart**. New landscape genetics approaches for assessing uncertainty in corridor identification: Examples using elk from the Yellowstone Ecosystem. *Journal of Fish and Wildlife Management*. In press.

Lane-deGraaf, K.E., S.J. Amish, *F. Gardipee, A. Jolles, **G. Luikart**, V.O. Ezenwa. 2014. Signatures of natural and unnatural selection: evidence from an immune system gene in African buffalo. *Conservation Genetics*, In press.

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Pariset L., S. Joost, P.A. Marsan, A. Valentini, and the Econogene Consortium. 2009. Landscape genomics and biased F_{ST} approaches reveal single nucleotide polymorphisms under selection in goat breeds of North-East Mediterranean. *BMC Genet*ics, 10:7 (doi: 10.1186/1471-2156-10-7).

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Allendorf, F.W., P.R. England, **G. Luikart**, G.A. Ritchie, and N. Ryman. 2008. Genetic effects of harvest on wild animal populations. *Trends in Ecology and Evolution,* 6:327-337.

Luikart, G., S., Zundel, D. Rioux, C. Miquel, K.A. Keating, J. T. Hogg, B. Steele, K. Foresman, and P. Taberlet. 2008. Low genotyping error rates for microsatellite multiplexes and noninvasive fecal DNA samples from bighorn sheep. *Journal of Wildlife Management*, 72:299-304.

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Muhlfeld C.C., R.P. Kovach, L.A. Jones, M.C. Boyer, R.F. Leary, W.H. Lowe, **G. Luikart**, and F.W. Allendorf. Invasive hybridization linked to climate change in a threatened salmonid species. In review.

Kovach, R., C.C. Muhlfeld, **G. Luikart** et al. Eco-evolutionary mechanisms influencing introgression of invasive genes into a threatened native trout species. In review.

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Amish, S., Y. Hoareau, *C. Almendra, N. Anderson, P.R. Clark, H. Edwards, R. Frey, *M. Gruber J. Henningsen, R. Wallen, **G. Luikart**. Sensitive pathogen detection in nonlethal and noninvasive ungulate samples using PCR. In review.

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*Antao, T., I.M. Hastings, **G. Luikart**, M.J. Donnelly. Estimating effective population size in disease vectors: a critical assessment of applications and performance. In review.

*Almandra, C. et al. Detecting brucellosis in wildlife: consequences for public health and disease eradication. In review.

*Antao, T., A. Pérez-Figueroa, I.M. Hastings, M.J. Donnelly, and **G. Luikart**. Interpreting estimates of effective population size and heterozygosity: caveat emptor! In review.

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Luikart, G. et al. Estimating the number of breeders (*Nb*) in threatened populations: Evaluations of new methods and SNP markers in salmonid species. In prep.

*Hand, B,K., et al. Landscape community genomics: predicting effects of landscape and climate variation on connectivity, adaptation, and multispecies interactions. In prep.

*Kardos, et al. Whole genome sequencing identifies candidate adaptive genes in wild bighorn sheep. In prep.

SELECTED GRANTS AND CONTRACTS AWARDED:

NASA-ROSES (Ecological forecasting for conservation): Projecting effects of climate change on river habitats and salmonid fishes. Funded. $200k for year 1 (2014) with possible extension to 3 additional years (@ $200k per year).

NSF-DEB: Evolutionary mechanisms influencing the spread of hybridization: genomics, fitness, and dispersal. Funded, $600k, 2013-2017.

NSF–EID (Ecology of infectious diseases): Effects of land-use and predation risk on wildlife contact networks and *Brucella* transmission in the Yellowstone Ecosystem. 2010-2014.

NSF-EID: Microparasite-Macroparasite Interactions: Dynamics of Co-infection and Implications for Disease Control. Co-PI with V. Ezenwa, A. Jolles, E. Nunn. 2007-2011.

NSF-IGERT: Montana Ecology of Infectious Diseases: Integrative Graduate Training on Multi-scalar Computational, Mathematical and Empirical Approaches to Complex Biological Problems. Added as co-PI with Bill Holben, Jesse Johnson, Jonathan Graham. 2006-2012.

NSF-OPUS: Evolutionary genetics and the conservation of exploited populations. DEB0639770. Co-PI Gordon Luikart with Fred Allendorf (PI). 2008-2011.

USGS-PNW Climate center: Predicting Climate Change Impacts on River Ecosystems and Salmonids across the Pacific Northwest: Combining Vulnerability Modeling, Landscape Genomics, and Economic Evaluations for Conservation. Funded 2012-2015. $220,000.

ARC (Australian Research Council) Linkage grant funding for a research project entitled "Genomics for persistence of Australia freshwater fish". P. Sunnucks et al. Funded 2010-2015. $60k,

USFWS: Development and application of SNPs for estimating the number of breeders in lake trout following suppression. 2012-2013.

MFWP: New DNA Markers to assess hybridization, local adaptation, and restoration success in bull trout. 2012-2015.

MFWP: Hundreds of new SNP markers to detect hybridization in westslope cutthroat trout. 2011-2015.

MFWP: Introgressive hybridization in westslope cutthroat trout. 2013-2016.

MFWP, and USFS: Development and Validation of Q-PCR Tests for Early Detection of *Dreissenid* mussels. 2011-2013.

Trout Unlimited: New SNP markers to detect local adapatation and hybridization in Lahontan cutthroat trout. 2011-2015.

MFWP: Application of SNPs for estimating the number of breeders in lake trout following suppression. 2014-2015.

USFS: Admixture and diversity assessments in westslope cutthroat trout of the Swan River drainage: SNP-chip analyses, 2011-2013.

SYNERGISTIC ACTIVITIES:

- **Development of Young Scientists**– I have mentored >50 university students, published with > 30, and helped occasional high school students in research projects.
- **Organizing international courses** on Population Genetic Data Analysis for graduate students, Portugal, 2006, 2008; for MS, PhD, postdocs and faculty, Montana, 2007, 2009, 2011, 2013; eg. www.popgen.net/congen2013 (2011)
- **Advising managers and conservation agencies** (selected examples)**–** Montana Fish Wildlife and Parks, cutthroat trout conservation committee, 2011-present, and co-author of bighron sheep conservation action plan; Swan Valley Trout Restoration Program advisor; Wild Fish Conservancy (WFC) consultant on hatcheries and wild salmon; Oregon law firms on hatcheries and wild salmon; IUCN Caprinae Specialists Group, taxonomy working group, 2001–present
- **Formal exchange program agreements**– Established between The University of Montana and The University of Porto, Portugal, 2007, 2009-present; Obtained funding for 6 students and 3 faculty from Montana to travel to and research in Portugal, 2006-present
- **Reviewer** (for numerous journals and agencies)**–** Examples: Biology Letters, Conservation Genetics, Nature Reviews Genetics, Proceedings of the Royal Society B, Science, Trends in Ecology & Evolution, Science, and U.S. Geological Survey, U.S. National Parks Service, U.S. National Science Foundation, NSF-EID panel member and reviewer.

ATTACHMENT C

HONORABLE THOMAS S. ZILLY

UNITED STATES DISTRICT COURT
WESTERN DISTRICT OF WASHINGTON
AT SEATTLE

WILD FISH CONSERVANCY, Plaintiff, v. PHIL ANDERSON, in his official capacity as the Director of Washington Department of Fish and Wildlife, *et al.*, Defendants,	)	No. 2:14-CV-00465-TSZ FIRST DECLARATION OF JACK A. STANFORD

I, Jack A. Stanford, declare the following on the basis of personal knowledge to which I am competent to testify:

1. My current address is 32111 BioStation Lane, Polson, Montana 59860. I have been retained as an expert on salmonid ecology and river ecology by the Plaintiffs in this matter;

PROFESSIONAL QUALIFICATIONS

2. I have 47 years of professional experience with the ecology of salmonid fishes and river ecology, including 38 years teaching at the university level. For most of my career I have specialized in research and teaching in the area of large river ecosystems, and since 1990

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my work has focused on large salmon-bearing rivers of the North Pacific Rim, Argentina and Norway;

3. I received a Ph.D. in Limnology (freshwater science) from the University of Utah in 1975, following a M.S. in Limnology and a B.S. in Fisheries Science, both from Colorado State University;

4. I have served in my current positions as director of the University of Montana's Flathead Lake Biological Station since 1980 and as the Jessie M. Bierman Professor of Ecology at the University of Montana since 1986;

5. I have worked at the Flathead Lake Biological Station since 1971. The Biological Station is a multidisciplinary research and education center with 8 resident faculty and some 50 staff members, including graduate students and postdoctoral scholars, with an annual budget currently exceeding $3 million from competitive grants;

6. My research and teaching encompass many aspects of fresh water ecology, including the natural and cultural interactions of large river ecosystems, food webs, nonnative species, salmon and steelhead life histories, aquatic species population dynamics, and river and salmonid conservation;

7. I have conducted numerous research investigations on these subjects, including long term studies of the Flathead River-Lake Ecosystem in Montana and British Columbia that demonstrated the pervasive food web changes caused by introduction of nonnative species, and extensive work comparing salmon and steelhead life histories and floodplain ecology across rivers in Kamchatka, Argentina, Alaska, and British Columbia;

8. I have authored or co-authored over 200 peer-reviewed research papers. The topics of these publications include salmon population collapse from shrimp stocking, Pacific

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salmon conservation, salmonid spawning, genetic diversity, and population structure. I also co-authored an article setting forth a general protocol for restoration of rivers regulated by dams in River Research and Applications that is the most-cited paper the journal has published to date;

9. In 2004, I received the Award of Excellence of the Society for Freshwater Science, and in 2011 I received the Lifetime Achievement Award from the International Society for River Science;

10. I have served on many national and international science review panels and editorial boards concerning the ecology and conservation of rivers and salmonid fishes. These duties include tenure on National Research Council panels on aspects of river ecology and 10 years on the Independent Science Advisory Board of the Northwest Power Planning Council evaluating proposals and plans for restoration of salmonid fishes in the Columbia River Basin. For over 20 years I have served on the editorial board of the journal River Research and Applications, I served one term on the editorial board of Ecological Applications, and I am currently on the board of the international electronic journal Peer J.;

11. I have substantial familiarity with interactions between wild and hatchery salmonids, ecological impacts from the introduction of nonnative salmonids, and the efficacy of salmonid population management and recovery efforts including restoration of flows in regulated rivers to create salmon habitat and restoration of riparian and shallow water habitat as rearing areas for juveniles;

12. Attached hereto as Exhibit 1 are my curriculum vitae, which include a list of the peer reviewed publications I have authored. My complete career publications list of over 200 papers can be viewed on the following Flathead Lake Biological Station website: http://www2.umt.edu/flbs/Research/Publications.aspx;

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13. I have not provided expert testimony at trial during the last four years. I have provided expert testimony during a deposition during the last four years in the matter of *Wild Fish Conservancy et al. v. National Park Service et al.*, W.D. Wash. 3:12-CV-05109-BHS;

14. I have not been compensated for my work in this matter up to this point. My current consulting hourly rate is $250. Thus far, I have spent approximately 40 hours in the matter;

15. In addition to drawing upon my knowledge and experience, I have reviewed the documents cited throughout this declaration and the following documents in developing my opinions expressed herein:

a. Hatchery and Genetic Management Plan, Kendall Cr. Winter Steelhead Hatchery Program, Washington Department of Fish and Wildlife (WDFW), updated February 10, 2014 (Nooksack River HGMP);

b. Hatchery and Genetic Management Plan, Marblemount Winter Steelhead Hatchery Program, WDFW, updated February 10, 2014 (Skagit River HGMP);

c. Hatchery and Genetic Management Plan, Snohomish Basin Winter Steelhead Hatchery Program, WDFW, updated February 10, 2014 (Snohomish River HGMP);

d. Hatchery and Genetic Management Plan, Whitehorse Ponds Winter Steelhead Hatchery Program, WDFW, updated February 10, 2014 (Stillaguamish River HGMP);

e. Hatchery and Genetic Management Plan, Dungeness River Early Winter Steelhead Hatchery Program, WDFW, updated February 7, 2014 (Dungeness River HGMP);

f. Hatchery and Genetic Management Plan, Soos Creek Hatchery Winter Steelhead Hatchery Program, WDFW, updated January 3, 2014 (Duwamish/Green River HGMP);

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g. A letter dated April 14, 2010, from George Pess, Jim Myers, and Jeff Hard of National Marine Fisheries Service's (NMFS) Northwest Fisheries Science Center to the Lower Elwha Klallam Tribe;

h. Impact of Hatchery Steelhead Smolt Release Levels on Wild and Hatchery Steelhead Survival Rates: Final Administrative Report, Saltonstall-Kennedy Project # NA08NMF4270424, April 11, 2013;

i. Ecological, Genetic and Productivity Consequences of Interactions between Hatchery and Natural-Origin Steelhead of the Skagit Watershed, March 2013;

j. NOAA Fisheries 2007 Puget Sound Steelhead Status Review, NOAA Technical Memorandum TM81. Hard, J.J., J.M. Myers, M.J. Ford, R.G. Cope, G.R. Pess, R.S. Waples, G.A. Winans, B.A. Berejikian, F.W. Waknitz, P.B. Adams. P.A. Bisson, D.E. Campton, and R.R. Reisenbichler. 2007, Status review of Puget Sound steelhead *(Oncorhynchus mykiss)*, U.S. Dept. Commer., NOAA, Tech. Memo. NMFS-NWFSC-81, p. 117;

k. "Historical abundance of Puget Sound steelhead, *Oncorhynchus mykiss*, estimated from catch record data" by N. Gayeski, B. McMillan, and P. Trotter published in the Canadian Journal of Fisheries and Aquatic Sciences, volume 68, pages 498 – 510, 2011;

16. I have also spoken with the following people in forming my opinions expressed herein: Dr. Gordon Luikart and Nick Gayeski;

SUMMARY OF OPINIONS

17. In summary, it is my professional opinion that WDFW's releases of the Chambers Creek hatchery stock winter-run steelhead as described in the Hatchery and Genetic Management Plans (HGMPs) referenced above:

a. harms wild Puget Sound steelhead through genetic interactions;

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b. harms and kills threatened Puget Sound Chinook, threatened Puget Sound steelhead, and threatened bull trout through various ecological interactions, including through competitive interactions and predation;

c. likely causes severe and long-term harm to the local wild winter-run steelhead populations in the rivers into which they are released, impairing their ability to contribute to the recovery of the Puget Sound steelhead distinct population segment (DPS) and thereby impairs the ability of the DPS to fully recover;

RISKS TO WILD FISH FROM HATCHERY OPERATIONS

18. Hatchery operations harm wild fish and inhibit the ability of depressed wild fish populations to recover through a variety of mechanisms;

19. Hatchery operations pose genetic threats to wild salmonids. Hatchery fish adapt through evolutionary processes to hatchery environments, making them less fit to survive and reproduce in the wild. This is especially true of hatchery steelhead from "segregated" hatchery programs (sensu the Hatchery Science Review Group (HSRG)) such as the Chambers Creek winter-run steelhead program that use highly domesticated hatchery broodstock developed to perform well in the hatchery environment so as to produce adult returns that can subsidize harvest opportunity. When these fish are allowed to interbreed with wild fish, the resulting offspring are less fit to survive and reproduce in the wild than the wild parent. Genetic threats include those caused by introgression of genetic material from hatchery fish into the native population through interbreeding. Genetic threats from introgression include:

a. loss of fitness and locally adaptive characteristics of the native population;

b. loss of genetic diversity within the native population; and

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c. loss of diversity among populations as explained in more detail in the Luikart Declaration;

20. In addition to these genetic threats, interbreeding of hatchery steelhead with wild steelhead has a negative demographic effect on the already depressed wild populations that results when the progeny of hatchery-wild matings return fewer or no adult offspring relative to wild-wild matings. This results in the total number of wild steelhead in the generation following hatchery-wild matings being smaller than it would be had the wild fish mated with other wild fish instead of with hatchery fish. Thus, even in the case where hatchery-wild matings result in zero genetic introgression (because progeny from these matings do not survive to reproduce as adults), hatchery-wild matings depress the abundance of the wild population;

21. The genetic and demographic threats that segregated hatchery stocks like the Chambers Creek steelhead stock pose to wild steelhead populations would not exist only where no adult hatchery steelhead strayed onto the spawning grounds of wild steelhead. This would require that all returning adult hatchery steelhead were either caught and killed in fisheries or returned to and enter the hatchery facility in the river basin to which they return. There is no evidence to my knowledge for any such segregated hatchery program in Puget Sound that this occurs (see, for example, Dauer et al. 2009);

22. On the contrary, it is likely that every year many returning Chambers Creek hatchery steelhead escape harvest and fail to return to the hatchery facility, remaining in the rivers where they will most likely attempt to spawn with wild steelhead. This is implicitly acknowledged in each of the HGMPs that I have reviewed, where it is admitted that the estimates of hatchery smolt-to-adult survival (SAR) are likely under-estimates because they are calculated only based on the estimated total in-river harvest and the return to the hatchery. In other words,

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the HGMPs admit that the SAR figures are underestimates because some adult hatchery fish are neither harvested nor return to the hatchery—those other hatchery fish stray onto the wild spawning grounds;

23. In my comments on each of the HGMPs below I show that with only modest and realistic increases in the estimated SARs, the hatchery adult steelhead that stray onto the wild spawning grounds would exceed the upper pHOS (proportion of hatchery-origin fish to the total number of spawners on the spawning grounds) limit of 5%. Lack of adequate monitoring of winter steelhead on the spawning grounds by WDFW means that a considerable proportion of the Chambers Creek hatchery steelhead that stray onto spawning grounds go undetected;

24. Hatchery operations also pose ecological threats to wild fish, which include:

a. competition with wild juvenile fish for local food resources and rearing space (territory);

b. competition with wild adults for spawning territory, which can include displacement of wild adults from preferred spawning locations;

c. preying on wild fish by hatchery fish;

d. disruption of normal migratory behavior of returning wild adult salmonids from passage barriers or false attractions to hatchery outfalls;

25. Hatchery salmonids are, in general, significantly more tolerant of high densities of conspecifics than native, wild, salmonids. Consequently, when local abundances of hatchery fish are sufficiently high, the competition with hatchery fish can result in displacement of native wild juveniles and adults to less optimal rearing, feeding, sheltering, and spawning locations. These significant disruptions to behavioral patterns can create the likelihood of injury, and can kill the native fish;

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26. Steelhead and salmon home to water in their natal rivers that contain strong odors of other salmon and steelhead. This is an evolutionary mechanism to increase the odds of finding mates. This is especially important to small populations recolonizing newly accessible habitats. The effluent water discharged from fish hatcheries contains highly concentrated odors of salmon and/or steelhead, compared to concentrations in a natural river. It is common for upstream migrating wild salmonids to be diverted to hatchery outfall waters and to enter hatchery holding ponds or to spend significant amounts of time and energy attempting to do so if the gates to the outfall are closed. Wild salmonids can be injured or even killed when they are handled in an effort to return them to the river. The delay in their upstream migration to natural spawning grounds caused by this "false attraction" to hatchery outfalls can result in wild individuals either not making it to the spawning grounds at all or not arriving in times to secure the best locations for spawning and thus having to compete more strenuously for mates and spawning sites than if they were not delayed. In addition to delay, steelhead and salmon commonly injure themselves on the structures that block the hatchery outfalls as they repeatedly attempt to swim or jump past these barriers;

27. Release of hatchery fish into the wild also poses a risk of introducing pathogens and parasites to wild populations that can result in temporary epidemics or permanent reductions in wild populations. While this risk is more difficult to quantify than genetic and competitive effects, they are unlikely to be negligible. Even a single hatchery individual carrying a pathogen to which local, native wild fish are susceptible can have devastating consequences. This is especially of concern with regard to local wild populations, including the majority of wild Sound winter-run steelhead population in Puget Sound, that are already at depressed levels of abundance;

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THREATENED PUGET SOUND SALMONIDS

28. The Puget Sound steelhead DPS was listed as a "threatened" species under the ESA in 2007, and remains so listed. As discussed in the First Declaration of Dr. Gordon Luikart (Luikart Declaration), Puget Sound wild steelhead numbers are approximately 1 to 4% of their historical abundance (Gayeski, et al. 2011, NMFS 2007);

29. The Puget Sound Chinook salmon evolutionary significant unit (ESU) is listed as a threatened species under the ESA;

30. Bull trout within the coterminous United States is listed as a threatened species under the ESA;

CHAMBERS CREEK STEELHEAD HATCHERY PROGRAMS IN PUGET SOUND

31. The Luikart Declaration describes the Chambers Creek steelhead hatchery stock used by WDFW in its Puget Sound hatcheries;

32. According to WDFW's HGMPs, WDFW currently releases Chambers Creek hatchery steelhead in the quantities and at the locations described in the following table:

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Chambers Creek Steelhead Hatchery Program	Targeted Annual Release Number	Release Sites
Nooksack River Program	150,000	Kendall Creek, Nooksack River
Skagit River Program	230,000	Cascade River
Stillaguamish River Program	140,000	Whitehorse Spring Creek, Stillaguamish River
Duwamish/ Green River Program	70,000	Soos Creek, Icy Creek, Green River
Snohomish River Program	150,000	Tokul Creek, Snohomish River
	20,000	Wallace River, Snohomish River
	160,000	Reiter Ponds, Skykomish River, Snohomish River
Dungeness River Program	10,000	Dungeness River
Total Release	**930,000**	

OPINIONS REGARDING WDFW'S CHAMBERS CREEK PROGRAMS

33. It is my opinion that the large releases of hatchery steelhead smolts from each of WDFW's Chambers Creek steelhead programs harm wild native Puget Sound winter-run steelhead smolts, juvenile bull trout, and Chinook salmon smolts through competition for food, rearing and sheltering space in the mainstems of the rivers into which they are released and associated estuary and nearshore environments. The large numbers of hatchery steelhead smolts typically released annually constitute significant modifications to the habitat of these wild threatened salmonids;

34. As reported in section 10.1 of the HGMPs, most or all of the hatchery smolts that WDFW releases are approximately 200 millimeters, or nearly 8 inches, long when they are released. Wild steelhead smolts are often as small as 150 mm and commonly 170 to 180 mm, 1

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to 2 inches smaller than the hatchery smolts. Most competitive interactions among juveniles of the same species are determined simply on the basis of size;

35. Competitive impacts will be intensified by the hatchery smolts' tolerance for higher densities (crowding) than wild smolts, which increases the probability that individual wild smolts experience competition from several larger hatchery smolts, instead of just one. This further increases the likelihood of competitive interaction being settled in favor of hatchery smolts and to the displacement of wild smolts from preferred rearing and migrating space;

36. Thus there is a high probability that, for each of WDFW's Chambers Creek steelhead programs, numerous wild smolts are outcompeted by hatchery smolts in the mainstem of rivers into which hatchery smolts are released and in the associated estuary and nearshore environments. Some wild native winter-run steelhead smolts, juvenile bull trout, and Chinook salmon will most likely be killed and injured by the releases from each of the six Chambers Creek steelhead hatchery programs due to competition for food, rearing, and sheltering space;

37. It is my opinion that some of the smolts WDFW releases each year for each of its six Chambers Creek steelhead hatchery programs will residualize, meaning that they will not migrate to salt water, but will instead remain in the river as resident "trout." Residualization is a common occurrence with hatchery steelhead (Naman 2008, Hausch & Melnychuk 2012, Melnychuk et al. 2014). The addition of these residualized hatchery fish constitutes a significant modification to the habitat of wild salmonids. These residualized hatchery fish will harm and most likely kill some rearing wild steelhead, rearing juvenile Chinook salmon, and bull trout through predation and competition for food and rearing and sheltering space. Significantly, the extent of residualization of hatchery fish is unmeasured in WDFW's HGMPs and apparently

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unmonitored; yet, it is a potentially significant limiting factor for wild steelhead in all Puget Sound rivers into which Chambers Creek hatchery steelhead are released;

38. It is my opinion that some ESA-listed salmonids will enter WDFW's Chambers Creek hatchery structures where their spawning migration will be delayed. Some of these fish will be injured and killed when efforts are made to remove them from the hatcheries' holding ponds—typically with nets—and returned to the river;

39. It is my opinion that the steelhead hatchery operations described in WDFW's several steelhead HGMPs will most likely cause severe and long lasting harm to the wild native Puget Sound winter run steelhead populations and to their ability to fully recover, and to the Puget Sound steelhead DPS to which those populations belong. Such harm will result, separately and in combination, from the fitness/genetic effects, the competition effects, and the predation effects. These hatchery programs will most likely hinder, and may even prevent, the full recovery of the wild native steelhead populations and the Puget Sound steelhead DPS;

40. It is my opinion that the hatchery programs described in WDFW's steelhead HGMPs should be immediately eliminated to prevent likely long term severe harm to the wild native Puget Sound winter-run steelhead DPS and its ability to fully recover;

CONCERNS REGARDING INDIVIDUAL CHAMBERS CREEK PROGRAMS

41. I have examined the tables in sections 1, 2, and 3 of each of the six HGMPs that provide data on recent hatchery escapements, freshwater harvest of hatchery fish, annual number of hatchery smolts released, estimated hatchery smolt-to-adult survival rates based on these numbers, and the number of wild adult steelhead estimated to have escaped to the spawning grounds or (in the case of the Dungeness River) estimated numbers of wild smolts emigrating from the river basin;

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42. Smolt-to-adult survival rates (SARs) for hatchery releases are reported in Table 3.3.1.1 in Section 3.3.1 in each of the six HGMPs. These SARs are calculated by simply dividing the sum of reported or estimated harvests in freshwater and the returns to the hatchery facility by the total number of hatchery smolts released two years prior to the adult returns. Section 1.12 of all six HGMPs notes that these SARs are minimum estimates that likely underestimate the true SAR for each of the smolt releases. Consequently, the HGMPs admit that the true number of hatchery-origin adults returning each year to each of the six river basins is likely to be somewhat greater than the total that is accounted for by in-river harvest plus returns to the hatchery;

43. The additional number of hatchery adults not accounted for in the freshwater harvest plus returns to the hatchery most likely end up on the spawning grounds with wild steelhead. I evaluated how much hatchery SARs reported in Table 3.3.1.1 of each HGMP would have to increase in order to produce enough additional hatchery adults (assuming that all such excess adults end up on the spawning grounds) straying onto the spawning grounds to generate a pHOS ("proportion of hatchery-origin spawners") of 5%—which means that 5% of the total number of adult fish on the spawning grounds are hatchery fish;

44. A pHOS of 5% is the upper limit recommended by the Hatchery Science Review Group (HSRG) for segregated hatchery program such as the Chambers Creek programs in Puget Sound. This level is also the upper limit allowed in WDFW's State Steelhead Management Plan (SSMP). This is intended as a surrogate measuring harm caused by genetic interactions between hatchery fish and wild fish. I am not endorsing this limit as measure for an appropriate level of harm to wild salmonids in performing my analyses and providing my opinions described herein;

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45. I find that the actual hatchery SARs would only need to be modestly greater than the estimated averages reported in Table 3.3.1.1 to equal or exceed a pHOS of 5%. Given that the HGMPs themselves admit that the estimated SARs provided are likely underestimated, it is highly likely that the actual SARs are sufficiently high to result in pHOS levels that equal or exceed the 5% upper limit;

46. I also compare the number of hatchery smolts currently released annually to recent estimates of the number of wild steelhead smolts in each river basin. This is used to evaluate the potential for the hatchery releases to result in harmful interactions with wild juveniles and the likely impacts of the releases on the recovery of wild steelhead;

47. For these analyses, I use the "Low Abundance Threshold" to provide a conservative frame of reference. This is the term employed by the Puget Sound Steelhead Technical Recovery Team (PSSTRT) in its population viability analysis of Puget Sound steelhead (PSSTRT 2013) as representing the number of wild steelhead that a river basin could be expected to sustain based on its current habitat capacity if the smolt-to-adult survival rate (SAR) were 1% (0.010). The SAR for wild salmon and steelhead in the absence of hatchery effects and severe freshwater habitat degradation is determined entirely by conditions in the marine environment, and thus beyond the control of management agencies responsible for freshwater habitat and hatchery production. Consequently, the Low Abundance Threshold can be understood as providing a minimum adult spawner abundance target for a rebuilding wild population under poor ocean conditions;

48. In its viability analysis, the PSSTRT considered the Low Abundance Threshold to be well below a "Viable Abundance Threshold," which is the expected level of abundance that could be attained if the SAR were 5 % instead of the 1%. When the abundance of the wild

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population is lower than the Low Abundance Threshold when the SAR is equal to or greater than 1%, as appears to be the case in the Dungeness River watershed and the Snohomish River watershed, that indicates that conditions in the freshwater are acting to depress the wild population below what should be expected based on current habitat conditions;

A. The Dungeness River Program.

49. WDFW's Dungeness River HGMP proposes annual releases of 10,000 hatchery smolts. The average SAR for steelhead smolts released from the Dungeness Hatchery two years prior to return years 2000/01 to 2012/13 is 0.0086 (0.86%) and 0.011 (1.1%) for the most recent 5 return year period (2008/09 to 2012/13). The data for the most recent five year period is more likely to reflect current conditions, so I focus my analysis on these data;

50. Unlike the other five HGMPs, the Dungeness River HGMP provides no estimate of recent spawning escapements of wild adults for the Dungeness River in Table 2.2.2.7. Instead, estimates are provided for wild smolts emigrating from the basin in the spring of 2005 to 2012. The average annual number of wild smolts during this period is 10,953, and 10,662 for the most recent five-year period corresponding to adult return years 2008/09 to 2012/13, assuming (as the HGMP does) that the majority of adults return two years after emigrating from the Dungeness as smolts;

51. Wild steelhead smolts are known to have higher SARs than hatchery steelhead. I assumed an SAR of 0.015 (1.5%), which is a modest 0.4% greater than the 0.011 recent five year average for Dungeness hatchery steelhead of 0.011, and is slightly greater than the SAR used by the Puget Sound Steelhead Technical Recovery Team (PSSTRT) to estimate the Low Abundance Threshold for Puget Sound steelhead populations based on the TRT's estimate of current habitat capacity for each Puget Sound steelhead population. From the five year average of 10,662 wild

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smolts, I estimated the numbers of wild steelhead that would have returned to the Dungeness in year 2007/08 to 2012/13 assuming a wild SAR of 1.5%. The average is 160. Eight hatchery adult steelhead on the spawning grounds would constitute a pHOS equal to the upper limit of 5% (8/160 = 5.0%). At the five-year average hatchery SAR of 1.1%, the total estimated adult return from the proposed release of 10,000 hatchery smolts -- that would be divided between harvest and hatchery escapement -- is 111. A total hatchery adult return of 119 under these conditions would result in a pHOS of 5%. An SAR of 0.0119 (1.19%) would generate this return from the smolt releases under this program of 10,000. This is a modest increase above the recent five year average hatchery SAR of 0.011 (1.1%) estimate provided in the HGMP, and easily within the range of normal environmental variation and measurement error;

52. I therefore conclude that is highly likely that the actual SAR for the hatchery program is such that the annual number of Chambers Creek hatchery steelhead smolts released under the Dungeness River Program result in a pHOS equal to or in excess of the 5% upper limit;

53. The Dungeness River HGMP also shows that the proposed hatchery releases are essentially equal to recent levels of wild smolt production in the Dungeness (10,000 vs. 10,662). Competitive interactions that act to depress the survival of wild steelhead (as described herein) are likely to occur during smolt outmigration and early residence in the estuary and nearshore, and from competition with and predation on juvenile pre-smolt steelhead in the river from those hatchery smolts that residualize;

54. The PSSTRT (PSSTRT 2013; Dungeness River HGMP Table 2.2.2.2, page 15) estimates the adult winter steelhead capacity of the Dungeness River at a wild smolt-to-adult survival rate (SAR) of 1% (the "Low Abundance Threshold") to be 246 adults. This would require wild smolt production of 24,600. If the wild SAR was 1.5% (the value I used to estimate

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a recent five year average return of 160 wild adults from 10,662 smolts), 16,400 wild smolts would be required to produce a return of 246. These are very minimal numbers of wild adults and smolts needed to begin rebuilding the wild steelhead population in the Dungeness River;

55. The 10,000 Chambers Creek-origin hatchery smolts released under this program have, in my opinion, a significant probability of acting to depress wild smolt survival so as to contribute to preventing the rebuilding of wild smolt numbers to the very minimal levels of 16,000 to 25,000 that is necessary to achieve the PSSTRT's Low Abundance Threshold, a number that is still well below any number that would reasonably permit the Dungeness to contribute to the recovery and de-listing of the Puget Sound steelhead DPS;

B. The Nooksack River Program.

56. WDFW proposes to release 150,000 hatchery smolts into the Nooksack River watershed. The average SAR for steelhead smolts released from this program is 0.0048 (0.48%) for the twelve year period 2000/01 to 2011/12, and 0.0014 (0.14%) for the most recent 5 year period. The average estimated wild winter steelhead return for the five year period is 1836. 92 adult hatchery steelhead on the spawning grounds would equal a 5% pHOS. At the average hatchery SAR of 0.14%, the total estimated adult return that would be divided between harvest and hatchery escapement is 216. A total return of 308 would result in 92 stray hatchery steelhead that produce a pHOS of 5%. Given the proposed release of 150,000 hatchery steelhead, an SAR of 0.21% (0.0021) would produce a return of 308 hatchery fish. This is a modest increase above the recent five year average hatchery SAR of 0.0014 (0.14%), and easily within the range of normal environmental variation and measurement error;

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57. I conclude that is highly likely that the actual SAR for this hatchery program is such that the annual releases of Chambers Creek hatchery steelhead smolts results in returns where the pHOS will equal or exceed the 5% upper limit;

58. If wild smolts survived half again (one and one-half as much) as well as hatchery smolts in the recent five year period, the wild SAR would be a paltry 0.0022 (0.22%). At this SAR, nearly 850,000 wild smolts would be required to produce the five-year average estimated wild return of 1836. 150,000 hatchery smolts is 18% of 850,000, and so relatively not as bad as the Dungeness River and other hatchery releases proposed in the HGMPs (see below). Nonetheless, the absolute number is significant and at such an extremely low estimated wild steelhead SAR, the estimated numbers of wild adults is still below the PSSTRT's estimated Low Abundance Threshold (2205);

59. Competitive interactions between hatchery and wild smolts can still contribute significantly to the depressed condition of wild Nooksack River winter steelhead. If, as is likely, the SAR of wild steelhead is significantly greater than 0.22%, the estimated average wild adult return of 1836 is produced by significantly fewer than 850,000 wild smolts, increasing further the likelihood of significant negative interactions with the 150,000 hatchery smolts. For example, if the wild SAR was 0.75% (0.0075) (the value estimated for smolts released from the winter steelhead conservation hatchery program on the Elwha River), fewer than 250,000 wild smolts would be needed to return 1836 adults;

C. The Skagit River Program.

60. Some statements in the Skagit River HGMP suggest that, at least parts of it, have yet to undergo a sound internal review for consistency and accuracy. Section 2.2.2, page 17, contains data for the estimated number of natural-origin (wild) Skagit River winter steelhead

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spawners in return year 2012-13 (8272). Yet this figure is not included in the Table of hatchery smolt releases and hatchery and wild adult returns in Section 2.2 (Table 2.2.2.9, page 21), which only contain data from return years 2001/02 to 2011/12. Moreover, for Table 3.3.1.1 on page 36 showing hatchery smolt releases and adult hatchery returns for years 2001/02 to 2011/12, footnote d indicates that the data for 2011/12 "is preliminary and subject to change." One would, therefore, suspect that any data for wild spawners for 2012/13 might also be provisional;

61. In any case, no other data for return year 2012/13 is reported in the Skagit River HGMP. The point of including the estimate of wild spawners in 2012/13 is apparently to support the statement (page 17) that the "number ...has substantially increased in the last five years." However, Table 3.3.1.1 shows this to be untrue. The five-year average of the data in table 2.2.2.9 is 4603. If the numbers for 2012/13 were accepted, the five year average for 2008/09 to 2012/13 would be 5280. In contrast, the five year average for years 2001/02 to 2005/06 is 6537. In my opinion, the statement that the number of wild spawners in the Skagit "has substantially increased in the last five years" is, at best, a considerable exaggeration and is not supported by the data contained in the Skagit River HGMP;

62. WDFW proposes to release 230,000 hatchery smolts into the Skagit River watershed annually. The average SAR for steelhead smolts released from this hatchery program is 0.0033 (0.33%) for the twelve year period 2000/01 to 2011/12, and 0.0035 (0.35%) for the most recent 5 year period. The average estimated wild winter steelhead return for the five year period is 4603. 230 hatchery steelhead would thus equal a 5% pHOS. At the five-year average hatchery SAR of 0.35%, the total estimated adult return from the proposed release of 230,000 hatchery smolts -- that would be divided between harvest and hatchery escapement -- is 800. A total return of 1030 would, therefore, result in 230 stray hatchery steelhead. Given the proposed

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release of 230,000 hatchery steelhead, an SAR of 0.45% (0.0045) would produce a return of 1030 resulting in a 5% pHOS. This is a modest increase above the recent five year average hatchery SAR of 0.0035 (0.35%), and easily within the range of normal environmental variation and measurement error;

63. I therefore conclude that is highly likely that the actual SAR for this hatchery program is such that the annual releases of Chambers Creek hatchery steelhead smolts under this program results in a pHOS that equals or exceeds the 5% upper limit;

64. If wild Skagit River winter steelhead smolts survive half again (one and one-half as much) as well as the hatchery smolts, then the wild SAR over the recent five-year period would have been 0.52%. 882,000 smolts would therefore produce an adult return of 4603. If the wild SAR is 1.0%, 460,000 wild smolts would be required. The PSSTRTs estimated Low Abundance Threshold for the Skagit River (which assumes an SAR of 1%) is 9427 for the entire basin, including the Nookachamps River, and 9304 for the Skagit, Sauk and Baker Rivers combined (Skagit River HGMP, Table 2.2.2.2, page 18). 942,700 wild smolts would be required to achieve the Low Abundance Threshold return of 9427 wild adults at an SAR of 1%. The 230,000 hatchery smolts proposed for release would amount to one-half the number of wild smolts if the recent wild SAR were 1%;

65. It is my opinion that releases of 230,000 hatchery smolts will have a high likelihood of contributing to the depression of wild adult returns through negative competitive interactions with wild smolts;

D. The Stillaguamish River Program.

66. WDFW proposes to release 140,000 hatchery smolts annually into the Stillaguamish River watershed. The average SAR for steelhead smolts released from this

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hatchery program is 0.0061 (0.61%) for the twelve year period 2000/01 to 2011/12, and 0.0032 (0.32%) for the most recent 5 year period. The average estimated wild winter steelhead return for the five year period is 300. 15 adult hatchery steelhead would therefore result in a 5% pHOS. At the five-year average hatchery SAR of 0.32%, the total estimated adult return from the proposed release of 140,000 hatchery smolts -- that would be divided between harvest plus hatchery escapement -- is 454. At total return of 469 hatchery steelhead would, therefore, generate 15 stray hatchery steelhead and produce a pHOS of 5%. Given the proposed release of 140,000 hatchery steelhead, an SAR of 0.33% (0.0033) would produce the needed return of 469. This is essentially identical to the recent five year average hatchery SAR of 0.0032 (0.32%);

67. It is therefore my opinion that it is highly likely that the actual SAR for this program is such that the annual releases of Chambers Creek hatchery steelhead smolts under this program will result in a pHOS equal to or in excess of the 5% upper limit;

68. A wild SAR half again (one and one-half as much) as large as the recent hatchery SAR would be 0.49%. At an SAR of 0.49%, 62,000 wild smolts would achieve the recent five-year average return of 300 wild adults. If the wild SAR were 1%, 30,000 smolts would return 300 adults. The PSSTRTs estimated Low Abundance Threshold for the Stillaguamish River winter-run steelhead population is 1912 adults and would require 191,200 smolts (Stillaguamish River HGMP, Table 2.2.2.2, page 15). These numbers all show the Stillaguamish wild winter-run steelhead population to be seriously depressed. The 140,000 hatchery smolts proposed for release in the Stillaguamish River HGMP is considerably greater (by factors of over 2-to-1 to as great as nearly 5-to1) than any estimates of recent wild smolt production;

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69. The likelihood that these releases would pose a considerable risk to the current wild steelhead population and prevent the rebuilding of the population towards the low abundance threshold is, in my opinion, extremely high;

E. The Snohomish River Program.

70. WDFW proposes to release 330,000 hatchery smolts into the Snohomish River watershed annually. The average SAR for steelhead smolts released from the Snohomish Basin Winter Steelhead Hatchery Program is 0.0129 (1.29%) for the twelve year period 2000/01 to 2011/12, and 0.0093 (0.93%) for the most recent 5 year period. The average estimated wild winter steelhead return for the five year period is 2123. 106 adult hatchet fish on the spawning grounds would result in a 5% pHOS. At the five-year average hatchery SAR of 0.93%, the total estimated adult return from the proposed release of 330,000 hatchery smolts -- that would be divided between harvest and hatchery escapement -- is 3069. At total return of 3175 would, therefore, result in 106 stray hatchery steelhead and a pHOS of 5%. Given the proposed release of 330,000 hatchery steelhead, an SAR of 0.96% (0.0096) would produce a return of 3175. This is a very small increase above the recent five year average hatchery SAR of 0.0093 (0.93%), and easily within the range of normal environmental variation and measurement error;

71. It is therefore my opinion that it is highly likely that the actual SAR for this program is such that the annual releases of Chambers Creek hatchery steelhead smolts under this program will result in a pHOS that will equal or exceed the 5% upper limit;

72. A wild SAR half again (one and one-half as much) as large as the recent hatchery SAR would be 1.4%. At an SAR of 1.4%, 152,000 wild smolts would achieve the recent five-year average return of 2123 wild adults. If the wild SAR were 1%, 212,300 smolts would be return 2123 adults. The PSSTRTs estimated Low Abundance Threshold for the Snohomish

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River winter-run steelhead population consisting of the Snohomish/Skykomish, Pilchuck, and Snoqualmie river populations is 4332 adults and would require 433,200 smolts (Snohomish River HGMP, Table 2.2.2.1, page 18) at the SAR of 1.0% from which the Low Abundance Threshold is derived. The recent abundance of wild winter-run steelhead in the Snohomish River Basin is less than one-half the estimated Low Abundance Threshold, which is a minimum target level of abundance for beginning to achieve population rebuilding. The maximum estimated wild smolt production of 212,300 -- required to produce the recent five-year average wild adult return of 2123, based on a wild SAR of 1% -- is less than two-thirds the number of hatchery smolts that WDFW proposes to release;

73. It is my opinion that the smolt releases under this program pose a considerably high risk to the current wild steelhead population and prevent the rebuilding of the population towards the low abundance threshold;

F. Duwamish/Green River Program.

74. WDFW proposes to release 70,000 hatchery smolts into the Duwamish/Green River watershed. The average SAR for steelhead smolts released from this hatchery program is 0.0032 (0.32%) for the twelve year period 2000/01 to 2011/12, and 0.0024 (0.24%) for the most recent 5 year period. The average estimated wild winter steelhead return for the five year period is 614. 31 adult hatchery steelhead on the spawning grounds would result in a 5% pHOS. At the five-year average hatchery SAR of 0.24%, the total estimated adult return from the proposed release of 70,000 hatchery smolts -- that would be divided between harvest and hatchery escapement -- is 169. A total return of 200 would, therefore, generate 31 stray hatchery steelhead and a pHOS of 5%. Given the proposed release of 70,000 hatchery steelhead, an SAR of 0.29% (0.0029) would produce a return of 200. This is a very small increase above the recent

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five year average hatchery SAR of 0.0024 (0.24%), and easily within the range of normal environmental variation and measurement error;

75. It is therefore my opinion that it is highly likely that the actual SAR for this program is such that the annual releases of Chambers Creek hatchery steelhead smolts under this program will result in a pHOS equal to or in excess of the 5% upper limit;

76. A wild SAR half again (one and one-half as much) as large as the recent hatchery SAR would be 0.36%, which is likely an unrealistically low value for even a depressed wild steelhead population that retains any potential for recovery. At an SAR of 0.36%, 170,000 wild smolts would be needed to achieve the recent five-year average return of 614 wild adults. If the wild SAR were 1%, a much more realistically value for depressed wild Puget Sound steelhead, 61,400 smolts would be needed to return 614 adults. The PSSTRTs estimated Low Abundance Threshold for the Green River winter-run steelhead population is 1977 adults, which would require 197,700 smolts (Duwamish/Green River HGMP, Table 2.2.2.1, page 17) at the SAR of 1.0% from which the Low Abundance Threshold is derived. The recent abundance of wild winter-run steelhead in the Green River Basin is less than one-third the estimated Low Abundance Threshold, which is a minimum target level of abundance for beginning to achieve population rebuilding. The maximum estimated wild smolt production of 212,300 -- required to produce the recent five-year average wild adult return of 614, based on assuming a wild SAR of 0.36% -- is nearly two-and-one-half times the number of hatchery smolts that WDFW proposes to release. If the wild SAR is as high as 1%, the number of hatchery smolts proposed to be released is more than 10% greater than the recent average number of wild smolts;

77. It is therefore my opinion that, in either case, the number of hatchery smolts WDFW releases under this program is likely to reduce the contribution that wild smolt

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production could be expected to make to the production of wild adults compared to no hatchery smolt production, and thereby inhibit the rebuilding of the wild population toward the minimal level of the Low Abundance Threshold;

I declare under penalty of perjury under the laws of the United States of America that the foregoing is true and correct.

Executed this 16th day of April, 2014.

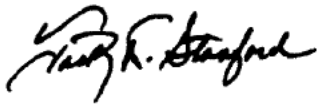

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EXHIBIT 1

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PERSONAL INFORMATION

U.S. citizen; born, February 18, 1947 (Delta, Colorado); married to Bonnie K. Ellis; 2 children (Jack A., Jr., Christian F.); avid skier, fly fisherman, conservationist.

EDUCATION

B.S.	Fisheries Science	Colorado State University, Ft. Collins	1969
M.S.	Limnology	Colorado State University	1971
Ph.D.	Limnology	University of Utah, Salt Lake City	1975

PROFESSIONAL POSITIONS

Director, Flathead Lake Biological StationThe University of Montana (1980–now). Administrative responsibility for all Biological Station activities including academic, research and community service programs. The Station is a center of excellence for hypothesis-oriented ecological, limnological and fisheries research conducted worldwide but focused on the Crown of the Continent region of Montana and British Columbia. FLBS has 8 faculty and 30 staff with a $3–6M annual budget. Associate Director for operations is Sue Gillespie. Assistant Director for facilities and properties is Mark Potter.

Jessie M. Bierman Professor of Ecology, The University of Montana (1986–now). Distinguished chair with permanent endowment, includes Directorship of the Flathead Lake Biological Station.

Associate Professor (1979–1980) and Assistant Professor (1974–1978), Department of Biological Sciences, North Texas State University (NTSU–now University of North Texas), Denton. Taught graduate and undergraduate ecology, biometrics and limnology. Studied primary and secondary production in southwestern reservoirs (H. H. Moss Reservoir, North Lake and Lake Texoma) and life history strategies of aquatic insects in the Brazos River, Texas. Also developed the Analytical Water Quality Laboratory in the Institute of Applied Sciences, NTSU, and continued limnological research on the Flathead River - Lake ecosystem in Montana.

Chairman, Ecology Division, Department of Biological Sciences, NTSU (1975–1977). Coordinator for development of academic programs and joint research projects within the Ecology Division (8 faculty).

Research Biologist and Instructor in Limnology, University of Montana Biological Station (1973–1974). Directed a limnological investigation of phytoplankton dynamics in response to nutrient input in Flathead Lake, while also completing doctoral research on ecology of stoneflies (Insecta:Plecoptera) in the Flathead River. Professor Arden R. Gaufin (deceased) – dissertation advisor, University of Utah, Department of Biology.

Graduate Teacher and Research Fellow in Zoology, Colorado State University, Fort Collins, Colorado (1969–1971). Developed an improved quantitative sampling procedure for use in an ecological study of the macrobenthic community of the Cache la Poudre River, Colorado. Dr. Edward B. Reed (deceased) – thesis advisor.

Fisheries Biologist, Alaska Department of Fish and Game, Dillingham, Alaska (1968–1969). Studied spawning habits of Pacific herring in Nunavarchuk Bay, Alaska, and escapement and reproductive ecology of five species of Pacific salmon in the Nushagak River, Bristol Bay.

Curator of Ichthyology Collection, Department of Fisheries and Wildlife, Colorado State University (1966–1969). Collected fishes throughout Colorado; conducted taxonomic study and cataloging for Professors Robert Behnke and Harold Hagen; prepared Ichthyology teaching materials for graduate TAs.

RESEARCH GOAL

To achieve a holistic understanding of natural (biophysical) and cultural (social) controls on biodiversity and bioproduction in a landscape ecosystem context.

CURRENT RESEARCH

- Development of a decision support system that will assist salmon conservation across the North Pacific Rim, based upon a robust classification (typology) of rivers and river habitats using remote sensing.
- Biodiversity and bioproductivity, as controlled by natural and cultural processes, of a suite of pristine Pacific salmon river ecosystems in the Russian Far East (Kamchatka), Alaska and British Columbia.
- Linkages between river ecology and the distribution and abundance of wild steelhead and trout and their relationships to and interactions with other biota.
- Floodplain ecology of gravel-bed rivers: groundwater controls on aquatic and riparian biodiversity and bioproduction in a landscape ecology context.
- Spatial and temporal linkages between terrestrial and aquatic components of large watersheds.
- Restoration ecology of large river systems, especially salmon rivers.
- Interactions between hydro-manipulation, nutrient loading and food webs in oligotrophic river-lake ecosystems.

TEACHING (See FLBS web site www.flbs/umt.edu for FLBS academic programs.)

Graduate – Various seminars and thesis/dissertation topics
Undergraduate – Field Ecology

HONORS

Fellowship, Nordic Council for Ecology, Universities of Oslo, Bergen and Trondheim, Norway (1980); Awarded distinguished and endowed Jessie M. Bierman professorship, University of Montana (1986); Fellowship, Foundation for Research Development, Republic of South Africa (1989); Golden Trout Award for Professional Service, West Slope Chapter, Trout Unlimited (1991); Nominated for PEW Scholarship in Conservation and the Environment (1995); Recipient of the Mershon Award of the Montana Academy of Science for Outstanding Scholarship (1996); Elected President of the Society for Freshwater Science (1996–1997); Elected President of the Organization of Biological Field Stations (1996–1998); Distinguished Scholar Award-The University of Montana (1997); Nominated for President

of the American Society of Limnology and Oceanography (1998); Nominated for the Earle A Chiles Award for Conservation (1999); Named a Fellow of the American Association for Advancement of Science (2000); Award of Merit issued by the Society for Technical Communication for a paper in Fisheries titled "Return to the River: Scientific issues in the restoration of salmonid fishes in the Columbia River," (2001); Award of Excellence-Society for Freshwater Science (2004); All time "Grizzly Great" - The University of Montana (2005); Lifetime Achievement Award - International Society of River Science (2011); Federation of Fly Fishers' Leopold Conservation Award (2011); Conservationist of the Year (with B.K. Ellis) - Montana Environmental Information Center (2012).

PROFESSIONAL MEMBERSHIPS

North American Benthological Society (Executive Committee 1979, 1987, 1988; Program Chair 1996, President 1996–97)
Ecological Society of America (Public Affairs Comm. 1993–1996)
Organization of Biological Field Stations (President 1996–1998, Executive Comm. 1996–2000)
Council of Aquatic Sciences (Chair 1998–2001)
International Society for Theoretical and Applied Limnology (National Representative, 2001–2004)
American Society of Limnology and Oceanography
American Association for the Advancement of Science
American Institute of Biological Sciences
Society for Conservation Biology
Northwest Scientific Association
American Fisheries Society
Montana Academy of Science
Sigma Xi
North American Lake Management Society
Association of Ecosystem Research Centers

EDITORIAL AND PEER REVIEW DUTIES

PeerJ (Board of Editors, 2013-now); River Research and Applications (Regional Editor, 1986–now); Ecological Applications (Board of Editors, 1996–99); Academic Press (Board of Editors, Aquatic Series, 1994–2003); Freshwater Invertebrate Biology (Board of Editors, 1982–84); National Science Foundation (Ecology Panel, 1985–88; Facilities for Field Stations and Marine Labs Panel, 1989–90; LTER site reviewer, 1992–93; LTER Supplementation Panel, 1993–94; Water and Watersheds Panel, 1995; Biocomplexity in the Environment Panel, 2001; National LTER Advisory Board, 2003–now); Independent Scientific Advisory Board for Fish and Wildlife Programs, Bonneville Power Administration and National Marine Fisheries Service (1990–98); National Academy of Science (National Research Council Panel on Watershed Science, 1996–97; Panel on Riparian Ecology 1999–00); U.S. Fish and Wildlife Service (review of Trinity River Flow Evaluation, 1998); Science Technical Committee, Alaska Sustainable Salmon Initiative (2005–now). Ad hoc reviewer for: National Academy of Science, National Science Foundation, American Fisheries Society, Science, Ecology, Canadian Journal of Fisheries and Aquatic Sciences, Conservation Biology, Oikos, Freshwater Science, Freshwater Biology, BioScience, Copea and other international journals in ecology.

SYMPOSIA ORGANIZED

First International Symposium on Regulated Streams (NSF), 1979 (with J. V. Ward); Community Structure and Function in Temperate and Tropical Streams (NSF), 1987 (with A. P. Covich); Workshop on Groundwater Limnology, 24th Congress of the International Association of Theoretical and Applied Limnology, Munich, West Germany, 1989 (with J. Gibert, G. Bretschko); Fifth International Symposium on Regulated Streams, Flathead Lake Biological Station, 1991 (with F. R. Hauer); National Workshops on Groundwater Ecology, Flathead Lake Biological Station (1995–2000); 1996 Annual Meeting of the North American Benthological Society (Program Chair), International Workshop on Riparian and Groundwater Ecology, Kastanienbaum, Switzerland, 1996 (with T. Gonser); Workshop on Data Bases and Networking, Organization of Biological Field Stations, National Center for Ecological Synthesis, Santa Barbara, CA., 1998 (with A. McKee), XI International Conference on Ephemeroptera XV International Symposium on Plecoptera 2004 Joint Meeting (with F. R. Hauer); 2006 Annual Meeting of the Organization of Biological Field Stations, Flathead Lake Biological Station, Polson, MT (with A. McKee).

BOOKS AND MONOGRAPHS

Ward, J. V. and J. A. Stanford (eds.). 1979. Ecology of Regulated Streams. Plenum Press, New York, New York, USA.

Ward, J. V. and J. A. Stanford. 1982. Thermal responses in the evolutionary ecology of aquatic insects. Annual Review of Entomology 27:97–117.

Stanford, J. A. and J. V. Ward. 1986. The Colorado River system, pp. 353–402. IN: Davies, B. R. and K. F. Walker (eds.), The Ecology of River Systems. Dr. W. Junk Publishers, Dordrecht, The Netherlands.

Stanford, J. A. and A. P. Covich (eds.). 1988. Community Structure and Function in Temperate and Tropical Streams. Proceedings of a Symposium, April 24–28, 1987, Flathead Lake Biological Station, The University of Montana. North American Benthological Society, Lawrence, Kansas. 261–529 pp.

Stanford, J. A. and J. J. Simons (eds.). 1992. Proceedings of the First International Conference on Groundwater Ecology. American Water Resources Association, Bethesda, Maryland. 420 pp.

Gibert, J., D. Danielopol and J. A. Stanford (eds.). 1994. Groundwater Ecology. Academic Press, San Diego, California, USA. 571 pp.

Stanford, J. A. and H. M. Valett (eds.). 1994**.** Proceedings of the Second International Conference on Groundwater Ecology. American Water Resources Association, Herndon, Virginia. 390 pp.

Naiman, R. J., J. J. Magnuson, D. M. McKnight and J. A. Stanford. 1995. The Freshwater Imperative: A Research Agenda. Island Press, Washington, DC. 165 pp.

Stanford, J. A. and T. Gonser. (eds.). 1998. Rivers in the Landscape: Riparian and Groundwater Ecology. Special Issue. Freshwater Biology 40(3):401–585.

Graf, W. L., C. J. Aichinger, B. P. Anderson, G. Benoit, P. A. Bisson, M. W. Garcia, J. P. Heaney, C. A. Johnston, L. J. Lane, C. H. Olsen, G. W. Petersen, M. J. Pfeffer, L. Shabman, J. A. Stanford and S. W.Trimble. 1998. New Strategies for America's Watersheds**.** National Research Council, National Academy Press, Washington, DC.

Brinson, M. M., L. J. MacDonnell, D. J. Austen, R. L. Beschta, T. A. Dillaha, D. L. Donahue, S. V. Gregory, J. W. Harvey, J. M. D. Molles, E. I. Rogers and J. A. Stanford. 2002. Riparian Areas: Functions and Strategies for Management [book online]. National Academy Press, Washington, District of Columbia, 444 pp. Available from: http://www.nap.edu/books/0309082951/html/.

Hauer, F. R., J. A. Stanford and R. L. Newell (eds.). 2008. International Advances in the Ecology, Zoogeography and Systematics of Mayflies and Stonefiles. UC Publications in Entomology, 128. University of California Press, Berkeley, California. 412 pp.

Pavlov, D. S., K. A. Savvaitova, K. V. Kuzishchin, M. A. Gruzdeva and J. A. Stanford. 2009. The Status and Monitoring of the Salmonid Biodiversity and Their Environment on Kamchatka (on the Territory of the "River Kol" Protected Area). KMK Scientific Press, Moscow, Russian Federation. 156 pp.

Stanford, J. A., R. R. Hauer, S. V. Gregory and E. B. Snyder. 2010. Columbia River Basin, pp. 258–283. IN: Benke, A. C. and C. E. Cushing (eds.), Field Guide to Rivers of North America. Elsevier, San Diego, California. 459 pp.

REFEREED PUBLICATIONS

Stanford, J. A. 1973. A centrifuge method for determining live weights of aquatic insect larvae with a note on weight loss in preservative. **Ecology** 54(2):449–451.

Stanford, J. A. and A. R. Gaufin. 1974. Hyporheic communities of two Montana rivers. **Science** 185(4152):700–702.

Stanford, J. A. and E. B. Reed. 1974. A basket sampling technique for quantifying riverine macrobenthos. **Water Resources Bulletin** 10(3):470–477.

Potter, D. S. and J. A. Stanford. 1975. Influences on plankton communities of oligotrophic Flathead Lake. **Verh. Internat. Verein. Limnol.** 19:1790–1797.

Stanford. J. A. and D. S. Potter. 1976. The Flathead Lake-River ecosystem: A perspective, pp. 241–250. IN: Soltero, R. (ed.), **Proceedings of ESA Symposium on Aquatic and Terrestrial Research in the Pacific Northwest**. Cheney, Washington. 397 pp.

Stanford, J. A., J. T. Boswell, D. P. Wilcox and W. B. Perry. 1977. Limnological application of the ATP assay in a mesotrophic Texas reservoir, pp. 311–328. IN: Borun, G. (ed.), **Second Biannual ATP Methodology Symposium**. SAI Technology Company, San Diego, California. 657 pp.

Sams, B. L., J. K. G. Silvey and J. A. Stanford. 1978. Comparative chemistry of a Texas cooling-water reservoir and its water source. **Journal Water Pollution Control Federation** 50:193–202.

Silvey, J. K. G. and J. A. Stanford. 1978. An historical overview of reservoir limnology in the Southwestern USA, pp. 1–18. IN: Cairns, J., E. Benfield and J. Webster (eds.), **Current Perspectives on River-Reservoir Ecosystems**. North American Benthological Society, Columbia, Missouri. 85 pp.

Stuart, T. J. and J. A. Stanford. 1978. A case of thermal pollution limited primary production in a southwestern USA reservoir. **Hydrobiologia** 58(3):199–211.

Perry, W. B., J. T. Boswell and J. A. Stanford. 1979. Critical problems with adenosine triphosphate (ATP) assays of planktonic biomass. **Hydrobiologia** 65(2):155–163.

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Boswell, J. T., W. B. Perry and J. A. Stanford. 1980. Analysis of plankton dynamics in a southwestern USA reservoir using ATP assays. **Internationale Revue der Gesamten Hydrobiologie** 65(1):155–167.

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Ellis, B. K. and J. A. Stanford. 1982. Comparative photoheterotrophy, chemoheterotrophy and photolithotrophy in a eutrophic reservoir and an oligotrophic lake. **Limnology and Oceanography** 27(3):440–454.

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Ward, J. V. and J. A. Stanford. 1984. The regulated stream as a testing ground for ecological theory, pp. 23–38. IN: Lillehammer, A. and S. Saltveit (eds.), **Regulated Rivers**. Oslo University Press, Norway.

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Perry, S. A., W. B. Perry and J. A. Stanford. 1987. Effects of thermal regime on size, growth rates and emergence of two species of stoneflies (Plecoptera: Taeniopterygidae, Pteronarcyidae) in the Flathead River, Montana, USA. **American Midland Naturalist** 117(1):83–93.

Valett, H. M. and J. A. Stanford. 1987. Food quality and hydropsychid caddisfly density in a lake outlet stream in Glacier National Park, Montana (USA). **Canadian Journal of Fisheries and Aquatic Sciences** 44(1):77–82.

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Ellis, B. K. and J. A. Stanford. 1988. Nutrient subsidy in montane lakes: fluvial sediments versus volcanic ash. Benthic faunal patterns along the longitudinal gradient of a Rocky Mountain river system. **Verh. Internat. Verein. Limnol.** 23:327–340.

Stanford, J. A., F. R. Hauer and J. V. Ward. 1988. Serial discontinuity in a large river system. Benthic faunal patterns along the longitudinal gradient of a Rocky Mountain river system. **Verh. Internat. Verein. Limnol.** 23:1114–1118.

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Hauer, F. R., J. A. Stanford and J. V. Ward. 1989. Serial discontinuities in a Rocky Mountain river. II. Distribution and abundance of Trichoptera. **Regulated Rivers: Research and Management** 3(1):177–182.

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Stanford, J. A. and J. V. Ward. 1989. Serial discontinuities in a Rocky Mountain river. I. Distribution and abundance of Plecoptera. **Regulated Rivers: Research and Management** 3(1):169–175.

Ward, J. V. and J. A. Stanford. 1989. Riverine ecosystems: the influence of man on catchment dynamics and fish ecology, pp. 56–64. IN: Dodge, D. P. (ed.), **Proceedings of the International Large River Symposium**. Special Publication of Canadian Journal of Fisheries and Aquatic Science 106.

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Ward, J. V. and J. A. Stanford. 1990. Ephemeroptera of the Gunnison River, Colorado, U.S.A., pp. 215–220. IN: Campbell, I. C. (ed.), **Mayflies and Stoneflies**. Kluwer Academic Publishers.

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Stanford, J. A., D. S. Pavlov, X. Augerot, K. V. Kuzishchin and others. 2005. SaRON Field Protocols for Cross-Site Comparison. Flathead Lake Biological Station, The University of Montana, Polson, Montana; Department of Ichthyology, Moscow State University, Moscow, Russia; The Wild Salmon Center, Portland, Oregon. 80 pp.

Ellis, B. K., J. A. Craft and J. A. Stanford. 2006. Monitoring water quality in Flathead Lake, Montana: 2006 Progress Report. FLBS Report 192-06. Prepared for Montana Department of Environmental Quality by Flathead Lake Biological Station, The University of Montana, Polson, Montana. 17 pp.

O'Neal, S. and J. A. Stanford. 2006. Population status and ecology of brown trout: Rio Grande, Tierra del Fuego, Argentina. FLBS Report 193-06. Submitted to Nervous Waters of Argentina and Estancia Maria Behety, Tierra del Fuego, Argentina by Flathead Lake Biological Station, The University of Montana, Polson, Montana, USA. 18 pp.

Ellis, B. K., J. A. Craft and J. A. Stanford. 2007. Monitoring water quality in Flathead Lake, Montana: 2007 Progress Report. FLBS Report 197-07. Prepared for Montana Department of Environmental Quality, Helena, MT by Flathead Lake Biological Station, Polson, MT. 25 pp.

Ellis, B. K., J. A. Craft and J. A. Stanford. 2008. Monitoring water quality in Flathead Lake, Montana: 2008 Progress Report. FLBS Report 202-08. Flathead Lake Biological Station, The University of Montana, Polson, Montana. 26 pp. FLBS Report 202-08. Prepared for, Polson, Montana. 26 pp.

Malison, R. L., J. A. Stanford and S. L. O'Neal. 2008. Population status and ecology of brown trout: Rio Grande, Tierra del Fuego, Argentina, 2008 season. FLBS Report 201-08. Prepared for Nervous Waters of Argentina and Estancia María Behety by Flathead Lake Biological Station, The University of Montana, Polson, Montana. 15 pp.

Mantua, N., N. G. Taylor, G. T. Ruggerone, K. W. Myers, D. Preikshot, X. Augerot, N. D. Davis, B. Dorner, R. Hilborn, R. M. Peterman, P. Rand, D. Schindler, J. Stanford, R. V. Walker and C. J. Walters. 2008. The salmon MALBEC project: a North Pacific-scale study to support salmon conservation planning. Submitted to North Pacific Anadromous Fish Commission by School of Aquatic and Fishery Sciences, University of Washington, Seattle, Washington, USA. 49 pp.

Ellis, B. K., J. A. Craft and J. A. Stanford. 2009. Monitoring water quality in Flathead Lake, Montana: 2009 Progress Report. FLBS Report 203-09. Flathead Lake Biological Station, The University of Montana, Polson, MT. 26 pp.

Lucotch, J. A., N. K. Maumenee, D. C. Whited, S. D. Chilcote, J. S. Kimball and J. A. Stanford. 2009. A Geographic Information Systems (GIS) Manual for the Development and Programming of the Riverscape Analysis Project (RAP) Data base and Interface. FLBS Report No. 204-09. Prepared for Gordon and Betty Moore Foundation, Palo Alto, California by Flathead Lake Biological Station, The University of Montana, Polson, Montana. 52 pp.

Ellis, B. K., J. A. Craft and J. A. Stanford. 2010. Monitoring water quality in Flathead Lake, Montana: 2010 Progress Report. FLBS Report 205-10. Flathead Lake Biological Station, The University of Montana, Polson, MT. 26 pp.

Stanford, J. A., W. Duffy, E. Asarian, B. Cluer, P. Detrich, L. Eberle, S. Edmondson, S. Foott, M. Hampton, J. Kann, K. Malone, and P. Moyle. 2011. Conceptual model for restoration of the Klamath River. Pages 151–174 in L. Thorsteinson, S. VanderKooi, and W. Duffy, editors. Proceedings of the Klamath Basin Science Conference, Medford, Oregon, 1–5 February 2010. U.S. Geological Survey Open-File Report 2011-1196.

Izurieta, C., S. Cleveland, I. Judson, P. Llovet, G. Poole, B. McGlynn, L. Marshall, W. Cross, G. Jacobs, B. Kucera, D. White, F. R. Hauer and J. Stanford. 2011. A cyber-infrastructure for a virtual observatory and ecological informatics systems - VOEIS, pp. Pages 76–81. IN: National Center for Ecological Analysis and Synthesis NCEAS Environmental Information Management EIM 2011, 29–30 September 2011, Santa Barbara, CA.

PAPERS PRESENTED BY INVITATION (72)

Stanford, J. A. 1974. Ecology of Montana stoneflies (Plecoptera). Institute of Water Research, Michigan State University, East Lansing. Host: Dr. Thomas G. Bahr.

Stanford, J. A. 1977. Thermal ecology of Rocky Mountain (USA) stoneflies (Plecoptera). Zoologish Museum, University of Oslo, Oslo, Norway. Host: Dr. Albert Lillehammer.

Stanford, J. A. 1977. Limnology of North Texas reservoirs and its interpretive value in studies of natural lakes. Texas Christian University, Fort Worth, Texas. Host: Dr. Ray Drenner.

Stanford, J. A. and J. K. G. Silvey. 1977. An historical overview of reservoir limnology in the Southwestern USA. Symposium on Problems Associated with River Impoundments, North American Benthological Society, Roanoke, Virginia. Host: Dr. John Cairns.

Stanford, J. A. 1979. Ecology of aquatic insects in the Flathead Rivers, Montana. Special Symposium on Ecology of Rocky Mountain Aquatic Insects. Entomological Society of America, Denver, Colorado. Hosts: Drs. J. V. Ward and R. K. Baumann.

Ward, J. V. and J. A. Stanford. 1980. The serial discontinuity concept of lotic ecosystems. Plenary Paper. Symposium on Dynamics of Lotic Ecosystems. Savannah River Ecology Laboratory and the University of Georgia, Athens, Georgia. Hosts: Drs. S. M. Bartell and T. D. Fontaine.

Stanford, J. A. 1981. Distribution of macroinvertebrates along heterogeneous gradients. American Geographical Society, Los Angeles, California. Host: Dr. Thomas Foggin.

Stanford, J. A. 1981. The role of limnological research in addressing critical water quality issues. Plenary Paper. Symposium on Montana's Water Future in the Decade of the '80's. Montana Academy of Science, Missoula, Montana. Host: Dr. A. Silverman.

Ward, J. V. and J. A. Stanford. 1981. The intermediate-disturbance hypothesis: An explanation for biotic diversity patterns in streams. Plenary Paper. Symposium on the Testing of General Ecological Theory in Stream Ecosystems. North American Benthological Society, Provo, Utah. Host: Dr. James Barnes.

Ward, J. V. and J. A. Stanford. 1982. The regulated stream as a testing ground for ecological theory. Plenary Paper. Second International Symposium on Regulated Streams, Oslo, Norway. Hosts: Drs. A. Lillehammer and S. Saltveit.

Stanford, J. A. 1984. The effects of the Cabin Creek mine on water quality in the Flathead Basin. Sigma Xi lecture. Montana College of Mineral Science and Technology, Butte, Montana. Host: Dr. D. Coe.

Stanford, J. A. and J. V. Ward. 1984. The Colorado River System. Symposium on Western Rivers. Ecological Society of America, Fort Collins, Colorado. Host: White House Staff

Ward, J. V. and J. A. Stanford. 1985. The ecology of regulated streams: Past accomplishments and directions for future research. Plenary paper. Third International Symposium on Regulated Streams, Edmonton, Alberta, Canada.

Ward, J. V. and J. A. Stanford. 1986. Riverine ecosystems: The influence of man on catchment dynamics and fish ecology. Plenary paper. International Large River Symposium. Honey Harbour, Ontario, Canada.

Stanford, J. A. 1989. Ecosystem science and management of natural resources in the Flathead Basin, Montana. Keynote address. Perspectives and Opportunities: Integrated Management of the Yakima River Basin. Central Washington University, Ellensburg, Washington. Host: Dr. Curt Wiberg. (Honorarium)

Stanford, J. A. 1989. Consequences of stream regulation on biodiversity and ecosystem stability and new approaches to management. Keynote address. Fourth South African National Hydrological Symposium, Pretoria, South Africa. Host: South African Foundation for Research Development. (Honorarium)

Stanford, J. A. 1990. Lake Powell and Colorado River water chemistry. Plenary paper. Symposium on Colorado River Ecology and Dam Management, Santa Fe, New Mexico. Host: Water Science and Technology Board of the National Research Council. (Honorarium)

Stanford, J. A. 1990. Ecosystem management in large watersheds regulated by dams and diversions. Plenary paper. New Perspectives for Watershed Management: Balancing Long-Term Sustainability with Cumulative Environmental Change. Seattle, WA. Host: University of Washington, Oregon State University, U.S. Forest Service and the Environmental Protection Agency.

Stanford, J. A. and B. K. Ellis. 1991. Non-native species as strong interactors controlling food web dynamics in oligotrophic lakes. Oregon State University. Corvallis, Oregon. Host: Dr. S. Gregory. (Honorarium)

Stanford, J. A. 1991. Distribution of groundwater organisms along geomorphic gradients in gravel bed rivers. Northern Arizona University, Flagstaff, AZ. Host: Dr. Dean Blinn. (Honorarium).

Stanford, J. A. 1991. Ecology of hyporheos in gravel bed rivers. Special Workshop Presentation. Annual Meeting of the North American Benthological Society. Santa Fe, NM. Host: Dr. Maurice Valett.

Stanford, J. A. and F. R. Hauer. 1991. The rivers of Lewis and Clark, then and now. Plenary Paper. Fifth International Symposium on Regulated Streams, Polson, Montana.

Stanford, J. A. 1992. Demonstrating the ecological connectivity between the channel and floodplain aquifers in gravel-bed rivers. Plenary Paper. First International Conference on Groundwater Ecology. Tampa, Florida. Hosts: EPA and AWRA.

Stanford, J. A. 1992. Reconnecting attributes of river ecosystems: A dynamic catchment approach to river conservation. Ernest O. Salo Seminar Series. Seattle, WA. Hosts: Dr. Robert Naiman and University of Washington. (Honorarium)

Stanford, J. A. 1993. Hyporheic insects of the Flathead River. Montana State University, Bozeman, Montana. Host: Florence Dunkel.

Stanford, J. A. 1993. Ecosystem function of springbrooks occurring on floodplains of alluvial rivers. Centre D'Ecologie Des Ressources Renouvelables - CNRS, Toulouse Cedex, France. Host: Prof. Henri DéCamps.

Stanford, J. A. 1994. Keynote Address. Ecosystem management of natural resources in the intermountain west, Logan, Utah. Host: Utah State University. (Honorarium)

Stanford, J. A. 1994. Watershed classification and analysis. Watersheds '94 Expo sponsored by the Environmental Protection Agency and the University of Washington Center for Streamside Studies. Bellevue, Washington. Host: Prof. R. J. Naiman. (Honorarium)

Stanford, J. A. 1995. Restoration of entire river catchments - a landscape perspective. Plenary Paper. International Workshop on Remedial Strategies in Regulated Rivers, Lycksele, Sweden. Host: John Britain.

Stanford, J. A. 1995. Flow dynamics, endangered fishes and floodplain ecology in the Colorado River. Symposium on the Colorado River. Ecological Society of America Annual Meeting, Snowbird, Utah. Host: Ray Hermann.

Stanford, J. A. 1996. River resources of the USA inland west: influences on cultures, economies and environments. Symposium on Fresh water: linking social, economic and environmental vitality. Ecological Society of America Annual Meeting, Providence, Rhode Island. Organized by Robert Naiman, John Magnuson and Penelope Firth.

Stanford, J. A. 1997. Conservation of fresh water: using our science to make a difference. Presidential Address. North American Benthological Society Annual Meeting, San Marcos, Texas.

Stanford, J. A. 1997. Rivers are more than what you see: hyporhiec ecology of alluvial flood plains. Plenary Address. American Fisheries Society Annual Meeting, Monterey, California. Organized by Charles Coutant.

Stanford, J. A. 1998. To burrow or not to burrow: The ecology of mayflies and stoneflies at the interface between surface and ground waters. Plenary Address. IX International Conference on Ephemeroptera and XIII International Symposium on Plecoptera, Tucuman, Argentina. Host: Hugo Fernandez.

Stanford, J. A. 1998. Protocol for integrated management of watershed ecosystems. Plenary Address. Toward ecosystem-based management in the Upper Columbia River Basin. An International Conference and Workshop, Castlegar, British Columbia.

Stanford, J. A. 1998. Role of science in conservation and restoration of river ecosystems. Invited Seminar. EAWAG-ETH Swiss Institute for Science and Technology, Zurich, Switzerland. Host: Dr. James V. Ward. (Honorarium).

Stanford, J. A. 1998. Flathead Lake as a natural-cultural ecosystem. Invited presenter at the International Fellows Meeting(IF – VIP Military leaders from 31 countries), Flathead Lake Lodge, Montana. Host: Doug Averill.

Stanford, J. A. 1999. One hundred years of ecological research at the Flathead Lake Biological Station. Invited Address. Beyond the NSF LTER Network: Lesser Known Long-Term Ecological Research. Ecological Society of America Annual Meeting. Spokane, Washington.

Stanford, J. A. 1999. Achieving a comprehensive aquatic conservation strategy on public lands: What scientists bring to developing sound policy. Ecological Society of America Annual Meeting, Spokane, Washington. Host: James Karr.

Stanford, J. A. 2000. The Normative River Concept. American Association for Advance of Science. Washington, DC. Hosts: Andy Rosenberg and Usha Varanasi.

Stanford, J. A. 2000. Rationale, criteria and documentation for normative flows in regulated rivers. Invited paper at the 8th International Symposium on Regulated Streams. Toulouse, France. Host: Henri Décamps

Stanford, J. A. 2000. Concepts and practices of the normative river concept and stream restoration. Invited Address for the National Research Council Committee on Missouri River Science Conference, July 9–10, 2000, Bismarck, ND. Host: Jeff Jacobs.

Stanford, J. A. and R. J. Naiman. 2001. Linking aquatic and terrestrial landscapes. Invited Paper at the Riverine Landscape Symposium, Ascona, Switzerland. Host: K. Tockner

Stanford, J. A. 2001. Mysids and other food web scourges. Congressional Briefing. The Organization of Biological Field Stations and National Association of Marine Laboratories Briefing on Invasive Species, February 20, 2001, Washington, DC.

Stanford, J. A. 2001. The need for ecosystem-level salmon conservation: Management lessons from salmon research in large floodplain river systems. Invited Paper at Pacific Wild Salmon and Steelhead Conference, November 5–6, 2001. Portland, Oregon.

Stanford, J. A. 2002 Biostation initiatives. Invited presentation at Scientific Oversight Committee Meeting, Center for Applied Biodiversity Science, Conservation International, February 25, 2002. Washington, DC

Stanford, J. A. 2002. The shifting habitat mosaic of flood plains and its importance to salmonid fishes. Plenary Paper. American Fisheries Society, Spokane, WA.

Stanford, J. A. 2002. Habitat condition and restoration potential of Columbia River flood plains: a critical, missing element of fisheries recovery science and policy. Invited seminar for Bonneville Power Administration, July 17, 2002. Portland, OR.

Stanford, J. A. 2003. Variability in Salmon River Landscapes: Factors Affecting Restoration Strategies. The World Summit on Salmon, June 12, 2003. Vancouver, BC, Canada.

Stanford, J. A. 2003. Long-term ecosystem science at Flathead Lake, Montana: The key to conservation of water quality. Keynote Address at Washington State Lake Protection Association. Chelan, WA.

Stanford, J. A. 2003. River Surna – Atlantic salmon: Effect of river regulation and management strategies. Seminar paper at the University of Oslo, Norway. Host: Svein Saltveit. (Honorarium)

Stanford, J. A. 2004. Reconciling fisheries with conservation in freshwater montane habitats. Keynote Address at 4th World Fisheries Congress. Vancouver, BC, Canada.

Stanford, J. A. 2004 Floodplain biocomplexity: Dynamic controls on emergent properties of river ecosystems. Plenary Lecture. International Association of Theoretical and Applied Limnology (Societas Internationalis Limnologiae, SIL), XXIX Congress. Lahti, Finland.

Stanford, J. A. 2005. Assessing real and potential productivity of salmon habitat in freshwater. State of the Salmon Conference, Anchorage, AK.

Stanford, J. A. 2006. Regulated river ecology: Three decades of regulated river research: Coherence of theory and practice. Keynote Paper. Tenth (and last) Symposium on Regulated Rivers. Stirling, Scotland.

Stanford, J. A. 2007. Sustaining wild salmon: Lessons from Kamchatka. Invited Presentation. Bevan Series on Sustainable Fisheries, University of Washington, School of Aquatic and Fishery Sciences, 22 February 2007, Seattle, WA.

Stanford, J. A**.** and M. S. Lorang. 2008. Self-organization of biophysical complexity in riverscapes. Invited Oral Presentation, North American Benthological Society (NABS) 56th Annual Meeting, 25–30 May 2008, Salt Lake City, UT.

Stanford, J. A. 2008. Salmon riverscapes: role of marine derived nutrients in the shifting habitat mosaic of river ecosystems. Keynote Address. Inland Northwest Aquatic, Riparian, and Wetland Symposium. Eastern Washington University 22–23, February 2008, Riverpoint Campus, Spokane, WA.

Stanford, J. A. 2008. Invited Speaker. “LeRoy’s River: Using science to mediate environment protection.” Aquatic Conservation Science: Merging Theory and Application Symposium. Odum School of Ecology, University of Georgia, 3–4 October 2008, Athens, GA.

Stanford, J. A. 2009. Keynote Speaker. “Self-organization of biophysical complexity in riverscapes: a fundamental tenet for ecohydrology.” Universidad de Concepción, 7th International Symposium on Ecohydraulics, 12–16 January 2009, Concepción, Chile**.**

Stanford, J. A. 2009. Oral Presentation. “Three decades of regulated river research: coherence of theory and practice.” Universidad de Concepción, 7th International Symposium on Ecohydraulics, Special Session on Dams, 12–16 January 2009, Concepción, Chile**.**

Ellis, B. E. and Stanford, J. A. 2009. Oral Presentation. “Marine derived nutrients in riverine food webs.” First Triennial Symposium for the International Society of River Science (ISRS), 12–17 July 2009, St. Pete Beach, FL.

Stanford, J. A. Oral Presentation. 2009. “Efficacy and selection of riverine protected areas to conserve wild pacific salmon.” First Triennial Symposium for the International Society of River Science (ISRS), 12–17 July 2009, St. Pete Beach, FL.

Stanford, J. A. 2009. Invited Speaker. "Climate change effects on Skeena River, British Columbia.” Skeena Salmon Habitat Conference, Bulkley Valley Centre for Natural Resources Research and Management, 15 September 2009, Smithers, BC, Canada.

Stanford, J. A. 2009. Invited Speaker. "Importance of Estuary-River linkages in salmon productivity." Estuary Habitat Expert Group (EHEG) Meeting. Tracey Yerxa, BPA, 8–10 October 2009, Portland, OR.

Stanford, J. A. 2009. Invited Speaker. "Aquatic Ecosystem Impacts of River Diversion for Hydro Power." Building a Vision for Green Energy in British Columbia, Simon Fraser University, 3 November 2009, Vancouver (done via electronic connection).

Stanford, J. A. 2009. Invited Speaker. "Climate warming, megamines and the energy glut: Can river, people, and their food webs adapt?" at Flathead Lake Biological Station, Polson, MT and Rudbach Lecture, Sigma Xi Lecture, The University of Montana, 7 December 2009, Missoula. MT.

Stanford, J. A. 2010. Invited Speaker. "A Conceptual Foundation for Ecosystem Restoration." Klamath Basin Science Conference, USGS, 2 February 2010, Medford, OR.

Stanford, J. A. 2010. Invited Speaker. "The Riverscape Analysis Project" Wild Salmon Ecosystems Initiative Partner's Workshop, Moore Foundation, 7–8 April 2010, Palo Alto, CA.

Stanford, J. A. 2010. Keynote Address. "Importance of wild salmon rivers." National Symposium on Ecological Interactions Between Wild and Hatchery Salmon, 4–7 May 2010, Portland, OR.

Stanford, J. A. 2011. Keynote Address. "Corridors and boundries: rivers, their floodplains and biota." 2nd Biennial Symposium of the International Society of River Science (ISRS), 8-12 August 2011, Berlin, Germany.

—One or two contributed papers have been presented or coauthored at annual meetings of professional societies each year since 1973.

RESEARCH GRANTS AND CONTRACTS ($33.6M)

Stanford, J. A. Ecological Studies of Texas Temporary Pools. NTSU Faculty Research Grant. $2,500. (1974)

Stanford, J. A. Plankton-Nutrient Dynamics in a North Texas Reservoir. NTSU Faculty Research Grant. $23,471. (1974, 1975)

Silvey, J. K. G., Director; J. A. Stanford, Associate Director. Training Grants in Water Supply, Water Quality and Pollution Control. U.S. Environmental Protection Agency. $180,000. (1975–1979)

Stanford, J. A. Lake Texoma Water Quality Study. U.S. Army Corps of Engineers, Tulsa, Oklahoma. $162,062. (1976–1979)

Stanford, J. A. Benthic Ecology in the South Fork of Flathead River, Montana, below Hungry Horse Dam. U.S. Bureau of Reclamation, Boise, Idaho. $7,100. (1977)

Tibbs, J. and J. A. Stanford. Construction of the Freshwater Research Laboratory, Flathead Lake Biological Station. The University of Montana, Fleishman Foundation. $1,000,000. (1978–1980).

Stanford, J. A. The Formation and Influence of Clay-Detritus Complexes in Relation to Temporal Carbon Dynamics in Three River-Lake Systems. NTSU Faculty Research Grant. $2,500. (1979)

Stanford, J. A. Limnology of the Flathead Lake-River Ecosystem, Montana. U.S. Environmental Protection Agency, Helena, Montana. $565,132. (1978–1983)

Stanford, J. A. and E. G. Zimmerman. Ecology of Big Pine Creek, Texas, with Emphasis on Temporal Carbon Dynamics. U.S. Army Corps of Engineers, Tulsa, Oklahoma. $55,000. (1979–1981)

Stanford, J. A. and T. L. Beitinger. Effects of Chronic pH Stress on Limnology and Fishery of an East Texas Lake. Ferndale Lake Club, Leesburg, Texas. $4,740. (1979)

Stanford, J. A. and J. V. Ward. First International Symposium on Regulated Streams. National Science Foundation. $15,220. (1979)

Stanford, J. A. and F. R. Hauer. Clean Lakes Study. Montana Department of Health and Environmental Sciences, Helena, Montana. $38,533. (1980–1981)

Stanford, J. A. and J. V. Ward. Evaluation of the Effects of Stream Regulation on the Limnology of the Gunnison River, Colorado. U.S. Environmental Protection Agency, Denver, Colorado. $40,098. (1979–1982)

Stanford, J. A., F. R. Hauer and J. N. Moore. Nutrient Subsidy in Alpine Lake Ecosystems by Volcanic Ash Import. U.S. Department of the Interior, Office of Water Research and Technology. $70,341. (1981–1982)

Stanford, J. A. Limnology of Whitefish Lake, Montana. Flathead County. $32,965. (1982–1983)

Stanford, J. A. Groundwater Resources Connected to Flathead Lake: Impact on Nutrient Mass Balance. Montana Department of Natural Resources. $100,000. (1983–1985)

Stanford, J. A. Verification of Sewage Leachates in Glacial Moraine Lakes. Office of Water Policy. U.S. Department of the Interior. $54,000. (1983–1985)

Stanford, J. A. A Water Quality Monitoring Program for Evaluating Management Options in the Flathead River Basin, Montana, with Emphasis on Determination of Phosphorus Bioavailability. Montana Department of Health and Environmental Sciences, Water Quality Bureau. $49,198. (1984–1985)

Stanford, J. A. and D. Kicklighter. The Use of Riffle Community Metabolism as a Measure of Water Quality in the Clark Fork River, Montana. Montana Department of Health and Environmental Sciences, Water Quality Bureau. $17,250. (1984–1985)

Stanford, J. A. Verification of Sewage Leachates in Whitefish Lake, Montana. Whitefish County Water and Sewer District. $26,106. (1984–1985)

Stanford, J. A. Bioavailability of Phosphorus Fractions in Tributary Waters of Flathead Lake, Montana. U.S. Environmental Protection Agency. $108,000. (1984–1985)

Stanford, J. A. Systems Analysis of the Cumulative Effects of Lake and Stream Regulation by Kerr Dam. Montana Power Company. $31,000. (1984–1987)

Stanford, J. A. Periphyton Dynamics in Flathead Lake. Bitterroot Fund, San Francisco. $12,000. (1985–1986)

Stanford, J. A. and F. R. Hauer. Aquatic Insect Ecology in the Lower Flathead River, Montana. Bureau of Indian Affairs. $50,000. (1985–1988)

Stanford, J. A. Limnology of Lakes in Glacier National Park. National Park Service. $114,400. (1982–1991)

Noble, R. A. and J. A. Stanford. Characterization of Suspended Sediment and Baseline Conditions - Proposed Cabin Creek Coal Mine - North Fork of Flathead River. Montana Bureau of Mines and Geology. $36,176. (1985–1988)

Stanford, J. A. and A. P. Covich. Workshop on Factors Controlling Community Structure and Function in Tropical and Temperate Streams. National Science Foundation. $59,900. (1987–1988)

Stanford, J. A. and F. R. Hauer. Research Vessel for Flathead Lake Biological Station. National Science Foundation. $88,000. (1987–1988)

Stanford, J. A. and J. V. Ward. Ecology of Riverine Hyporheos. National Science Foundation. $220,000. (1987–1989)

Stanford, J. A. and M. S. Lorang. Sediment Dynamics on the North Shore of Flathead Lake, Montana. Montana Power Company. $29,600. (1988)

Hauer, F. R., J. A. Stanford and C. N. Spencer. Water and Stream Ecosystem Quality as Effected by Forest Management Practices. Flathead Basin Commission. $72,501. (1989–1990)

Stanford, J. A. Independent Scientific Group. Pacific States Marine Fisheries Commission and Columbia Basin Fish and Wildlife Foundation. $402,228. (1989–1999)

Stanford, J. A. Analysis of the Interrelationship of Ecological Studies to Proposed Fish, Wildlife and Erosion Mitigation Plans in the Flathead Lake Area. Montana Power Company. $35,000. (1989–1991)

Stanford, J. A. and B. K. Ellis. Monitoring the Limnology of Two Subalpine Lakes in the Bob Marshall Wilderness, Montana: Quantifying Sensitivity to Acidic Precipitation. USDA Forest Service. $72,447. (1989–1995)

Stanford, J. A. and F. R. Hauer. Effects of Stream Regulation in the Upper Missouri River. Montana Power Company. $188,000. (1989–1994)

Spencer, C. N. and J. A. Stanford. Differential Impacts of *Mysis relicta* on the Plankton of Flathead and Swan Lakes. Montana Department of Fish, Wildlife and Parks. $50,000. (1990–1991)

Stanford, J. A., F. R. Hauer, L. F. Marnell, S. W. Running, A. L. Sheldon and C. N. Spencer. Complex Interactions in Large Oligotrophic Lakes: Nonnative Species as Strong Interactors Controlling Spatial and Trophic Linkages. National Science Foundation (EPSCoR). $204,421. (1990–1994)

Stanford, J. A., F. R. Hauer, C. N. Spencer and B. K. Ellis. Data Acquisition and Management System for Flathead Lake Biological Station. National Science Foundation. $82,640. (1990–1993)

Stanford, J. A. and B. K. Ellis. Relation Between Discharge and Distribution of Hyporheic Habitat within Selected Stream Segments in Glacier National Park, Montana. National Park Service. $114,500. (1990–1994)

Spencer, C. N., F. R. Hauer and J. A. Stanford. Comparative Effects of Wildfire on Pristine Streams in Glacier National Park Versus Streams on Managed Timber-Harvest Lands. National Park Service. $50,000. (1990–1994)

Stanford, J. A. and B. K. Ellis. Analyses of Long-Term Limnological Data Collected on Lakes in Glacier National Park. National Park Service. $6,500. (1991–1992)

Stanford, J. A. A Diagnostic Study of the Nutrient Loading in Flathead Lake, Montana (Phase I Project, Clean Lakes Program of the USEPA). Montana Water Quality Bureau. $100,000 (1991–1993)

Stanford, J. A. Complex Interactions in Large Oligotrophic Lakes: Nonnative Species as Strong Interactors Controlling Spatial and Trophic Linkages. National Park Service (CPSU). $9,500. (1991 – 1993)

Hauer, F. R. and J. A. Stanford. Long-Term Influence of Hungry Horse Dam Operation on the Ecology of Macrozoobenthos of the Flathead River. Montana Department of Fish, Wildlife and Parks. $25,000. (1992–1994)

Hauer, F. R. and J. A. Stanford. Effects of Climate Change on Hydrologic Systems and Associated Aquatic Biotas. National Park Service (CPSU). $504,000. (1992–1999)

Stanford, J. A. A Diagnostic Study of the Nutrient Loading and Sediment Bioavailability at Swan Lake, Montana (Phase I Project, Clean Lakes Program of the USEPA). Montana Water Quality Bureau. $142,909. (1992–1995)

Stanford, J. A. Review of Instream Flow Methods and Recommendations for the Endangered Fishes of the Upper Colorado River Basin. U.S. Fish and Wildlife Service. $120,821. (1992–1993)

Stanford, J. A. Review and Synthesis of Lotic Studies in Zion National Park. National Park Service (CPSU). $36,000. (1992–1994)

Frissell, C. A. and J. A. Stanford. Potential Effects of Climate Change in Thermal Complexity and Biotic Integrity of Streams: Seasonal Intrusion of Nonnative Fishes. U.S. Environmental Protection Agency. $370,000. (1993 –1995)

Frissell, C. A. and J. A. Stanford. A Strategy for Conservation of Aquatic Biodiversity in the Northern Rocky Mountains Ecosystem. Pacific Rivers Council. $82,764. (1993–1995)

Stanford, J. A. Expert Witness for Virgin River Adjudication. U.S. Department of Justice, Environment and Natural Resources Division. $15,301. (1993)

Stanford, J. A. Development of a Guidance Document for States to Protect Critical Zones of GW/SW Interaction. National Park Service (CPSU). $150,000. (1993–1999)

Hauer, F. R. and J. A. Stanford. Effects of Stream Regulation on the Macrozoobenthos of the Kootenai River. Montana Department of Fish, Wildlife and Parks. $37,517. (1994–1996)

Stanford, J. A. Review of Experimental Instream Flows to Protect and Enhance Riverine Resources in the Grand Canyon. Arizona State University. $15,269. (1994)

Stanford, J. A. Expert Witness Research and Testimony: Snake River Adjudication. U.S. Department of Justice, Environment and Natural Resources Division. $68,312. (1994–1998)

Stanford, J. A. Identification of Specimens of Invertebrates Collected in Zion National Park, Utah. Zion National Park, Utah. $1,500. (1994–1995)

Stanford, J. A. Workshop on Research Agenda for Sustainability of Montana Ecosystems. Bureau of Reclamation. $35,000. (1994–1995)

Stanford, J. A. Peer Review Recovery Implementation Program: Upper Colorado River Endangered Fishes. U.S. Fish and Wildlife Service. $4,418. (1994–1995)

Stanford, J. A. and B. K. Ellis. Flathead Lake Total Maximum Daily Loads. Montana Department of Health and Environmental Sciences. $15,000. (1994–1995)

Stanford, J. A. and F. R. Hauer. Monitoring of Surface Water Quality in the Flathead Basin: A Proposal for Modification of the Master Plan of the Flathead Basin Commission. Flathead Basin Commission. $52,686. (1994–1996)

Stanford, J. A., F. R. Hauer, N. M. Butler and B. K. Ellis. Lake Water System, Boat Dry Dock and Replacement of Obsolete Instruments at the Flathead Lake Biological Station. National Science Foundation. $130,000. (1994–1996)

Ellis, B. K. and J. A. Stanford. Developing a Lake-Specific Water Quality Target for Flathead Lake. Flathead Basin Commission. $115,000. (1995–1997)

Stanford, J. A. Review of Science Pertaining to the Fish and Wildlife Plan. Northwest Power Planning Council. $127,600. (1995–1996)

Stanford, J. A. Instream Flow Needs of Aquatic Biota of the Gunnison River, Black Canyon National Monument, Colorado. National Park Service (CPSU). $12,631. (1995–2000)

Stanford, J. A. and A. D. Barnosky. Determinants of Biodiversity, Social and Economic Patterns in Montane Ecosystems. National Science Foundation, EPSCoR. $1,806,639. (1995–1999)

Stanford, J. A. and J. Pastor. Grizzly Bear Digging in Subalpine Meadows: Influences on Plant Distributions and Nitrogen Availability. National Science Foundation. $259,478. (1995–1999)

Stanford, J. A. The Impact of River Recreation on the North Fork of the Virgin River, Zion National Park: A Comparative Analysis of Zoobenthos Biomass. National Park Service (CPSU**)**. $15,389. (1996–1997)

Ellis, B. K. and J. A. Stanford. Baseline Water Quality Study of Little Bitterroot, Mary Ronan, Ashley and Lindburgh Lakes, Montana. Plum Creek Timber Company. $78,842. (1996–1998)

Ellis, B. K. and J. A. Stanford. Determination of Nutrient and Carbon Loading in the Swan River, Montana. Montana Department of Environmental Quality. $30,224. (1997–1999)

Ellis, B. K. and J. A. Stanford. Water Quality of Goat and Lion Creeks. Friends of the Wild Swan, Inc. $17,905. (1997–1998)

Stanford, J. A. Independent Scientific Review Panel (ISRP). Northwest Power Planning Council. $30,750. (1997)

Stanford, J. A. The Teanaway River Enhancement Project. Bureau of Reclamation. $57,000. (1997–2000)

Stanford, J. A. Ongoing Peer Review of Effort to Produce a Report that Defines a Process for Establishing Biologically-Based Instream Flow Recommendations for the Yakima River Basin. Bureau of Reclamation. $20,580. (1997–1998)

Ellis, B. K. and J. A. Stanford. Water Quality of Selected Headwater Streams of the Flathead National Forest. Swan Ecosystem Center. $500. (1998–1999)

Ellis, B. K., J. A. Craft and J. A. Stanford. Water Quality of Selected Headwater Streams of the Flathead National Forest. USDA Forest Service, Flathead National Forest. $38,675. (1998–2000)

Stanford, J. A. Ground Water-Surface Water Interaction Training Workshop. U.S. Environmental Protection Agency. $24,900. (1998)

Stanford, J. A. Review and Synthesis of Data Related to Instream Flow Provision in the Yakima River Ecosystem, Washington. Bureau of Reclamation. $149,541. (1998–2000)

Stanford, J. A. Ground Water-Surface Water Interaction Training Workshop. U.S. Environmental Protection Agency. $25,000. (1999)

Stanford, J. A. Study of Surface and Groundwater Interactions in Five Reaches of the Yakima River. Bureau of Reclamation. $767,719. (1999–2001)

Wicklum, D. and J. A. Stanford. Ecology of *Mysis relicta* on Flathead Lake. Confederated Salish and Kootenai Tribes. $53,968. (1999)

Ellis, B. K., T. S. Bansak and J. A. Stanford. Effects of Wildfire on Nutrient and Sediment Transport in Skyland and Dodge Creeks, Flathead National Forest. USDA Forest Service, Flathead National Forest. $2,981. (1999–2000)

Stanford, J. A. Snake River Resources Review - Biologically Based River/Reservoir Systems Management Assessment Strategy. Bureau of Reclamation. $8,000. (1999–2000)

Stanford, J. A. Yakima Basin Side Channel Survey and Rehabilitation. Yakama Indian Nation. $154,255. (1999–2001)

Stanford, J. A. and F. R. Hauer. FSML: Equipment to Enhance Research and Electronic Data Management at Flathead Lake Biological Station. National Science Foundation. $99,205. (1999–2001) (with cost share)

Stanford, J. A. and J. S. Kimball. Analysis of Flow and Habitat Relations in Yakima River Associated with Proposed Water Exchange. Bureau of Reclamation. $300,000. (1999–2001)

Hauer, F. R., M. S. Lorang and J. A. Stanford. Floodplain Ecology of the Snake River, Idaho and Wyoming: Development of Biologically-Based System Management. Bureau of Reclamation. $431,284. (2000–2003)

Stanford, J. A. Ground Water-Surface Water Interaction Training Workshop. U.S. Environmental Protection Agency. $25,000. (2000)

Stanford, J. Impact of Flow Regulation on Riparian Cottonwood Ecosystems. Bioquest International Consulting, Ltd. $16,000. (2000–2001)

Stanford, J. A. Diet, Spatial Distribution and Life History of *Neomysis mercedis* in John Day Pool. Bonneville Power Administration. $180,539. (2000–2002)

Stanford, J. A. Biocomplexity Incubation Activity: Dynamic Controls on Emergent Properties of River Flood Plains. National Science Foundation. $101,010. (2000–2003)

Stanford, J. A. Limnological Survey of Ptarmigan Lake. National Park Service. $18,000. (2000–2003)

Wicklum, D. and J. A. Stanford. The Productivity of Flathead Lake. Confederated Salish and Kootenai Tribes. $59,402. (2000–2001)

Ellis, B. K. and J. A. Stanford. Analysis of Potential Sources of Nutrient Pollution Reaching Flathead Lake from Atmospheric Fallout. Flathead Basin Commission. $10,000. (2001)

Stanford, J. A. Ground Water-Surface Water Interaction Training Workshop. U.S. Environmental Protection Agency. $25,000. (2001).

Stanford, J. A. Flathead Lake TMDL. Montana Department of Environmental Quality. $10,000. (2001)

Stanford, J. A. Critical Lands Project. Flathead Lakers. $5,829. (2001)

Stanford, J. A. Yakima River Water Enhancement Project. Bureau of Reclamation. $10,000. (2001–2004)

Stanford, J. A. Continuing American Participation in the Kamchatka Wild Salmon Sanctuary Project. Trust For Mutual Understanding. $30,000. (2001–2002)

Stanford, J. A. and J. Craft. Revisit the Limnology of Whitefish Lake. Whitefish County Water and Sewer District. $75,000. (2001–2003)

Stanford, J. A., F. R. Hauer, J. S. Kimball and M. S. Lorang. Biocomplexity-Dynamic Controls on Emergent Properties of River Flood Plains. National Science Foundation. $2,600,000. (2001–2005)

Stanford, J. A., F. R. Hauer, J. S. Kimball and M. S. Lorang. REU Supplement: Biocomplexity – Dynamic controls on emergent properties of river flood plains. National Science Foundation. $15,750. (2001–2005)

Stanford, J. A., F. R. Hauer, J. S. Kimball and M. S. Lorang. REU Supplement: BCP cost share. National Science Foundation. $2,250. (2001–2005)

Stanford, J. A., F. R. Hauer, J. S. Kimball and M. S. Lorang. REU Supplement: FSML cost share. National Science Foundation. $1,500. (2001–2005)

Stanford, J. A. Ground Water-Surface Water Interaction Training Workshop. U.S. Environmental Protection Agency. $25,000. (2002)

Hauer, F. R., M. S. Lorang and J. A. Stanford. Floodplain Ecology of the Snake River, Idaho and Wyoming: Development of Biologically-Based System Management. Bureau of Reclamation. $191,000. (2000–2003)

Stanford, J. A. Continuing American Participation in the Kamchatka Wild Salmon Sanctuary Project. Trust For Mutual Understanding. $35,000. (2003)

Stanford, J. A. and B. K. Ellis. Groundwater quality assessment and monitoring plan for the North Flathead Valley and Flathead Lake perimeter. Flathead Basin Commission (regrant of Environmental Protection Agency funds). $26,946. (2003)

Stanford, J. A. Ground Water-Surface Water Interaction Training Workshop. U.S. Environmental Protection Agency. $25,000. (2003)

Stanford J. A. and F. R. Hauer. FSML: Site improvement and equipment enhancement to secure long-term research capabilities at Flathead Lake Biological Station. National Science Foundation. $171,451. (2002–2005) (with cost share)

Stanford, J. A. and F. R. Hauer. REU Supplement to FSML: Site improvement and equipment enhancement to secure long-term research capabilities at Flathead Lake Biological Station. National Science Foundation. $12,000. (2003–2005)

Relyea, S. E. and J. A. Stanford. Water quality monitoring of the Whitefish River and its tributaries. Montana Department of Environmental Quality. $50,000. (2003–2005)

Stanford, J. A. Ground Water-Surface Water Interaction Training Workshop. U.S. Environmental Protection Agency. $25,000. (2004)

Stanford, J. A. and J. S. Craft. Limnological studies of Fish Creek, Glacier National Park. National Park Service CESU. $2,350. (2004–2005)

Gannon, J., W. Holben, M. Rellig, W. Woessner and J. A. Stanford. Nyack microbial observatory project. National Science Foundation Microbial Observatory Program. $1,126,154. (2004–2006)

Stanford, J. A. Rapid assessment of salmonid ecology in the headwater rivers of Tierra del Fuego with emphasis on lands managed by the Wildlife Conservation Society. Wildlife Conservation Society. $29,000. (2005)

Stanford, J. A. Modeling studies to support Pacific salmon conservation planning. University of Washington. $109,223. (2006–2007).

Stanford, J. A.. Nyack microbial observatory project MCB-0348773. National Science Foundation Microbial Observatory Program. $288,959. (2004–2010)

Stanford, J. A. and F. R. Hauer. Population status and ecology of brown trout Rio Grande, Tierra del Fuego, Argentina. Nervous Waters of Argentina. $145,000. (2006–2008)

Stanford, J. A. The Salmonid Rivers Observatory Network (SaRON): Relating habitat and quality to salmon productivity for Pacific Rim rivers. Gordon and Betty Moore Foundation. $4,620,000. 2007–2010

Stanford, J. A. and S. Chilcote. Remote analysis of aquatic habitat areas – Pebble Mine. The Nature Conservancy. $20,000. (2008)

Stanford, J. A. Kamchatka Salmon and Biodiversity Project (KSBP). Wild Salmon Center. $796,916. (2003–2008).

Stanford, J. A. Ecology of North American salmon rivers. Gordon and Betty Moore Foundation. $1,600,842. (2003–2008)

Stanford, J. A. Crown of the Continent REU program. National Science Foundation. $220,575. (2004–2008)

Stanford, J. A. AYK sustainable salmon initiative research and restoration plan. Bering Sea Fishermen's Association. $41,760. (2004–2007)

Stanford, J. A. Hierarchical typology of north Pacific Rim rivers and application to wild salmon conservation. Gordon and Betty Moore Foundation. $1,659,533. (2005–2008)

Stanford, J. A. Modeling studies to support Pacific salmon conservation planning. University of Washington. $63,504. (2006–2009).

Stanford, J. A. AYK sustainable salmon initiative. Bering Sea Fishermen's Association. $30,992. (2006–2008)

Stanford, J. A. The Salmonid Rivers Observatory Network (SaRON): Relating habitat and quality to salmon productivity for Kamchatka rivers. Gordon and Betty Moore Foundation. $992,160. (2007–2010)

Rillig, M. C., D. L. Mummey and J. A. Stanford. Succession and changing roles of arbuscular mycorrhizal fungal communities in a floodplain chrono-sequence model system. National Science Foundation. $200,000. (2006–2008)

McPhee, M. V., T. P. Quinn and J. A. Stanford. Ecotypic variation in AYK sockeye stocks. Arctic-Yukon-Kuskokwim Sustainable Salmon Initiative (AYK-SSI). $242,403. (2008–2010)

Ellis, B. K., J. A. Stanford and J. A. Craft. Flathead Monitoring Project. Flathead Basin Commission, Montana Department of Environmental Quality, Bureau of Reclamation and Agency Consortium. $2,672,200. (1984–2012)

Stanford, J. A, B. K. Ellis and F. R. Hauer. Collaborative research: FSML-enhanced cooperative research and education at Flathead Lake Biological Station and Taylor Wilderness Research Station (in collaboration with University of Idaho, James R. Gosz, PI). National Science Foundation. $155,377. (2009–2012)

Hauer, F. R., A. J. Hansen, J. A. Stanford and M. J. Young, Collaborative Research: Cyberinfrastructure for a virtual observatory and ecological informatics system (VOEIS). National Science Foundation. $2,998,589. (2009–2012)

Stanford, J. A. Columbia River Estuary Science Panel Work Session. PC Trask & Assoc., Inc. $3,679. (2009–2010)

Stanford, J. A. Icicle Creek Mykiss sample analysis. Wild Fish Conservancy. $1,263. (2009–2010)

Stanford, J. A. Kuskokwim River tributary biological baseline production assessment. U.S. Fish and Wildlife Service, Yukon Delta National Wildlife Refuge. 12/09 – 6/10 = $10,637. (2009–2010)

Stanford, J. A. Development of a series of salmon science white papers. Gordon and Betty Moore Foundation. $21,000. (2010–2011)

Stanford, J. A. Kuskokwim River tributary biological baseline production assessment. U.S. Fish and Wildlife Service, Yukon Delta National Wildlife Refuge. $40,137. (2010–2011)

Stanford, J. A. Linking salmon portfolios to geomorphology of Pacific Rim rivers. University of Washington. $284,016. (2010–2012)

Stanford, J. A. Consulting services for restoration of the Colorado River Delta. Walton Family Foundation. $28,336. (2011)

Stanford, J. A. Expert report in relation to potential impacts on fish and water of the Enbridge Northern Gateway Pipelines project. West Coast Environmental Law. $16,000. (2011)

Stanford, J. A. Columbia River Estuary Science Panel Work Session. PC Trask & Assoc., Inc. $6,685. (2011)

Stanford, J. A. Enbridge impact mapping project., NW Institute for Bioregional Research. $25,000. (2011–2012)

Stanford, J. A. Columbia River Estuary Science Panel Work Session. PC Trask & Assoc., Inc. $2,408. (2012)

Stanford, J. A. Planning a Consortium for Systems Ecology Research and Applicaitons, Walton Family Foundation. $370,239. (2012)

Stanford, J. A. RiverNet expertise for the Taylor Wilderness Research Station, University of Idaho. $2,472. (2012)

Stanford, J. A. Chinook salmon expert panel process, Bering Sea Fishermen's Association. $6,500. (2012)

ENDOWMENTS AS OF 10/14/12

Jessie M. Bierman Professorship in Ecology at FLBS – $1.3M (1986, 1995)
McKnight Foundation Professorship in Limnology at FLBS – $1M (2001)
Scholarships at FLBS – $1.1M
Research Endowments – $475K

GRADUATE STUDENTS MENTORED (14 PH.D., 27 M.S., 4 M.A.; TOTAL 45)

1. Comparative chemistry of thermally stressed North Lake and its water source, Elm Fork Trinity River. M.S. Thesis by Barry L. Sams, 1976. (NTSU)

2. Limitation of primary productivity in a southwestern reservoir due to thermal pollution. M.S. Thesis by Tom J. Stuart, 1977. (NTSU)

3. The use of ATP assays in describing the limnology of H. H. Moss Reservoir, Texas. Ph.D. Dissertation by James T. Boswell, 1977. (NTSU)

4. Relation between carbon assimilation and biomass dynamics in a phytoplankton community. M.S. Thesis by Douglas P. Wilcox, 1977. (NTSU)

5. Seasonal and vertical distribution of organic carbon and biomass in H. H. Moss Reservoir, Texas. M.S. Thesis by William B. Perry, 1978. (NTSU)

6. Phytoplankton-salinity relationships in Lake Texoma. M.S. Thesis by William C. McCullough, 1978. (NTSU)

7. Distribution and population dynamics of zooplankton in Lake Texoma. M.S. Thesis by Larry B. Crist, 1979. (NTSU)

8. Size fractionation of metabolically active phytoplankton and bacteria in three diverse lake systems. M.S. Thesis by Bonnie K. Ellis, 1980. (NTSU)

9. Population dynamics of benthic macroinvertebrates in response to altered thermal and salinity regimes in the Brazos River, Texas. M.S. Thesis by James D. Coulter, 1981. (NTSU)

10. Ecological studies of Trichoptera in the upper Flathead Rivers, Montana. Ph.D. Dissertation by F. Richard Hauer, 1980. (NTSU)

11. The effects of freshet turbidity on selected aspects of biogeochemistry and trophic status of Flathead Lake, Montana. Ph.D. Dissertation by Thomas J. Stuart, 1983. (NTSU)

12. Consequences of fluctuating discharges from Hungry Horse Reservoir on benthic and larval fish ecology in the Flathead River, Montana. Ph.D. Dissertation by Sue A. Perry, 1985. (NTSU)

13. Limnology of Whitefish Lake, Montana. M.A. Thesis by Thomas Golnar, 1985. (University of Montana - OBE)

14. Trophic ecology of net-spinning caddisflies (Hydropsychidae) in the Flathead Rivers, Montana. M.A. Thesis by Maurice Valett, 1986. (University of Montana - OBE)

15. The use of riffle community metabolism as a measure of water quality in the Clark Fork River, Montana. M.S. Thesis by David Kicklighter, 1987. (University of Montana - EVST)

16. Effects of nutrient enrichment and lake level fluctuation on the shoreline periphyton of Flathead Lake, Montana. M.A. Thesis by Carolyn Hooper-Bauman, 1988. (University of Montana - OBE)

17. An ecological study of a regulated palouse prairie stream. M.S. Thesis by Juan Bosco Imbert, 1990. (University of Montana - OBE)

18. Ecology of an impacted northern Rocky Mountain stream. M.S. Thesis by Darlene Nardi, 1993. (The University of Montana - EVST)

19. Ecology of juvenile yellow perch in Lolo Bay, Flathead Lake, Montana M.S. Thesis by Michael Pol, 1993. (The University of Montana - OBE)

20. Distribution and abundance of zoobenthos in channel, springbrook and hyporheic habitats of an alluvial flood plain. M.A. Thesis by Georgia Case, 1995. (The University of Montana - OBE)

21. Phenologies of Plecoptera in the Virgin River, Zion National Park, Utah. M.S. Thesis by Mikel Shakarjian, 1997. (The University of Montana - EVST)

22. Phenology of *Mysis relicta* and influences on zooplankton of Flathead Lake. Ph.D. Dissertation by Dale Chess, 1998. (The University of Montana - OBE)

23. Grizzly bear digging in subalpine meadows: plant distributions and nitrogen availability. Ph.D. Dissertation by Sandra Tardiff, 1998. (The University of Montana - OBE)

24. Metabolism of hyporheos of the Flathead River, Montana. M.S. Thesis by James Craft, 1998. (The University of Montana - OBE)

25. Controls on seston dynamics alpine lakes. Ph.D. Dissertation by Dan Wicklum, 1998. (The University of Montana - OBE)

26. Determinants of primary production hot spots on alluvial flood plains. M.S. Thesis by Thomas Bansak, 1998. (The University of Montana - OBE)

27. Experimental fertilization of disturbance plots associated with grizzly bear digging in subalpine meadows. M.S. Thesis by Allison Young, 1998. (The University of Montana - OBE)

28. Analysis and dynamic simulation of morphologic controls on surface- and ground-water flux in a large alluvial flood plain. Ph.D. Dissertation by Geoffrey Poole, 2000. (The University of Montana -Forestry)

29. Ecology and population structure of cottonwoods on the Nyack Flood Plain, Montana. M.S. Thesis by Mary Harner, 2001. (The University of Montana - EVST)

30. Introduced *Mysis relicta*: Implications for pelagic food web structure and function. Ph.D. Dissertation by Craig P. Stafford, 2002. (The University of Montana - OBE)

31. The ecology of an invasive estuarine Mysid, *Neomysis mercedis*, in John Day Reservoir, Columbia River. M.S. Thesis by Craig Haskell, 2003. (The University of Montana - OBE)

32. Long-term osprey *(Pandion haliaetus)* population dynamics in relation to food web change at Flathead Lake, Montana. M.S. Thesis by Brandon Jackson, 2003. (The University of Montana - OBE)

33. Ecology of parafluvial ponds. Ph.D. Dissertation by Samantha Chilcote, 2004. (The University of Montana - OBE)

34. The importance and seasonal variation of terrestrial invertebrates as prey for juvenile salmonids on the Kol River Floodplain, Kamchatka, Russian Federation. M.S. Thesis by Lorri Eberle, 2007. (The University of Montana - OBE)

35. Sedimentary legacy of sockeye salmon (*Oncorhynchus nerka*) and climate change in an ultra-oligotrophic, glacially-turbid British columbia nursery lake. M.S. Thesis by Aaron Hill, 2007. (The University of Montana - OBE)

36. Amphipods are strong interactors in the food web of a brown water salmon river. M.S. Thesis by Audrey Thompson, 2007. (The University of Montana - OBE)

37. Lessons to learn from all out invasion: life history of brown trout (*Salmo trutta*) in a Patagonian river. M.S. Thesis Sarah O'Neal, 2008. (The University of Montana – OBE)

38. The edge effect: lateral habitat ecology of an alluvial river flood plain. Ph.D. Dissertation by Michelle Anderson, 2008. (The University of Montana - OBE)

39. The contribution of spawning Pacific-salmon to nitrogen fertility and vegetation nutrition during riparian primary succession on an expansive flood plain of a large river. Ph.D. Dissertation by Michael Morris, 2008. (The University of Montana - OBE)

40. Ecology of riverine sockeye in the Kwethluk River, Alaska. M.S. Thesis by Tyler Tappenbeck, 2008. (The University of Montana - OBE)

41. History, ecology and restoration potential of salmonid fishes in the Umpqua River, Oregon. M.S. Thesis by Kelly Crispen, Graduated 2010, defended 2011. (The University of Montana - OBE)

42. The ecology of parafluvial ponds on a salmon river. M.S. Thesis by Zachary J. Crete, 2012. (The University of Montana – Environmental Studies)

43. Ecology of Beaver and Salmon in a large Floodplain River. Ph.D. Candidate to finish 2013, Rachel Malison. (The University of Montana – Systems Ecology)

44. Salmon Dynamics and Brown Bear Behavior, Kodiak Island, Alaska, Ph.D. research ongoing. William Deacy. (The University of Montana – Systems Ecology)

45. Food web ecology of the Nyack Aquifer. Ph.D. research ongoing, Amanda Delvecchia. (The University of Montana – Systems Ecology).

46. Reconstructions of Historic Salmon Runs using Baysian Inference. Ph.D. research ongoing. Nick Gayeski (The University of Montana – Systems Ecology)

POST DOCTORAL SCHOLARS SPONSORED (CURRENT AFFILIATION)

Thomas M. Gonser – Swiss Institute of Science and Technology, Zurich
Martin Pusch – Leibniz-Institute of Freshwater Ecology and Inland Fisheries, Berlin, Germany
Eric M. Snyder – Grand Valley State University, Michigan
Maria Laura Miserendino – Centro Nacional Patagónico University, Esquel, Argentina
Hugo M. Fernandez – Nacional University, Tucaman, Argentina
Samantha D. Chilcote – US Forest Service, Shasta-Trinity National Forest Headquarters
Megan V. McPhee – University of Alaska, Juneau
Matt Luck – Rubenstein School of Natural Resources and Environment, University of Vermont
Huan Wu – University of Maryland Goddard Earth Sciences and Technology Center
Meredith Wright – USDA, Albany, California
Ashley Helton – University of Conneticut, Storrs

EXTRAMURAL COLLEAGUES OF LONG ASSOCIATION

James V. Ward – Swiss Institute of Technology (ETH), Zurich. (retired)
Svein J. Saltveit – University of Oslo, Norway
Klement Tockner – Leibniz-Institute of Freshwater Ecology and Inland Fisheries, Berlin, Germany
Charles A. S. Hall – State University of New York, Syracuse
Dmitry S. Pavlov – Russian Academy of Science, Moscow
Kirill V. Kuzishchin – Department of Ichthyology, Moscow State University, Russian Federation
Geoff Poole – Montana State University, Bozeman
Dan Goodman – Montana State University, Bozeman

SYNERGISTIC ACTIVITIES

- Frequent participant in national and international colloquia on strategic research agendas to sustain ecosystem goods and services (e.g., The Freshwater Imperative; National Environmental Observatory Network; Long-Term Ecological Research network).
- Gratis Consultant to The Nature Conservancy, Trout Unlimited, Gunnison River (Colorado) Coalition.
- Board Member of the Flathead Lakers, a conservation organization dedicated to the protection of Flathead Lake (1986–1990).
- Member of Finley Point (Montana) Volunteer Fire Department (1985–1994).
- Co-operator of Yellow Bay Advanced Wastewater Treatment Plant (1980–now).
- Public Speaker on environmental issues (several invited presentations per year, some international).
- Expert Witness, U.S. Congress on environmental issues: Senate Committee on Environment and Public Works (hearings on clean water and endangered species); Senate Subcommittee on Science and Technology (hearings on salmon restoration).
- Co-operator (with B. K. Ellis) of Duckhaven Ranch, an intermountain prairie wetlands restoration and education site located adjacent to the Ninepipes National Waterfowl Production Area, Ronan, Montana (1990–present).
- Expert Witness in successful adjudication of virgin river flows as permanent Federal reserve water rights for Glacier, Yellowstone and Zion National Parks.
- Founder of Nyack Flood Plain Research Natural Area, Middle Flathead River, Montana.
- Board Member of the Wild Salmon Center, Portland, Oregon (2003–2011). Conservation NGO dedicated to preservation of wild salmon and wild salmon rivers.
- Board Member of the Wild Fish Conservancy, Duval, Washington (2013-now). Conservation NGO dedicated to preservation of wild fish and wild fish habitat in the Pacific Northwest.

ATTACHMENT D

Steve Leider - NOAA Federal <steve.leider@noaa.gov>

Comments on Puget Sound DEIS from Trout Unlimited

1 message

John McMillan <jmcmillan@tu.org> Tue, Jan 20, 2015 at 12:06 PM
To: "steve.leider@noaa.gov" <steve.leider@noaa.gov>
Cc: "barry.thom@noaa.gov" <barry.thom@noaa.gov>, "will.stelle@noaa.gov" <will.stelle@noaa.gov>, "james.scott@dfw.wa.gov" <james.scott@dfw.wa.gov>

Dear Steve Leider

Attached you will find comments from Trout Unlimited regarding the Puget Sound DEIS. We appreciate the opportunity to comment on this important process and look forward to working collaboratively on finding smart solutions to the problems facing ESA-listed steelhead in Puget Sound.

Have a great week.

Sincerely

John R. McMillan

John R. McMillan | Science Director, Wild Steelhead Initiative

TROUT UNLIMITED

Cell & work: 360.797.3215, **Email:** john.mcmillan@tu.org, **Web:** www.tu.org

TU Comment on PS HGMP DEIS 1-19-15.pdf

January 23, 2015

Steve Leider
NMFS Sustainable Fisheries Division, West Coast Region
510 Desmond Drive SE, Suite 103
Lacey, WA 98503

Sent via email to: ***steve.leider@noaa.gov***

Re: Comments on Puget Sound Hatchery Program DEIS

Dear Mr. Leider:

Trout Unlimited (TU), the nation's largest coldwater fisheries conservation organization dedicated to protecting and retoring our nation's trout and salmon resources and the watersheds that sustain them, appreciates the opportunity to submit this letter as comment on NOAA's Draft Environmental Impact Statement regarding two Resource Management Plans developed jointly by the Washington Department of Fish and Wildlife and the Puget Sound treaty tribes (hereafter referred to collectively as the co-managers), covering more than 100 Puget Sound hatchery programs (hereafter referred to as the Hatchery DEIS). The Hatchery DEIS was published in July 2014, and the period for written public comment was extended to January 23, 2015.

Introduction

As noted in the document itself, "The purpose of an EIS under NEPA is to promote disclosure, analysis, and consideration of the broad range of environmental issues . . . by considering a full range of reasonable alternatives." (S-6) Moreover, the specific purpose this Hatchery DEIS is intended to serve is "to ensure the sustainability and recovery of Puget Sound salmon and steelhead by conserving the productivity, abundance, diversity, and distribution of listed species of salmon and steelhead in Puget Sound." (S-4) It is with these purposes in mind that TU submits its comments. Our objective is to ensure that the final Environmental Impact Statement analyzes an adequate range of alternatives and fully and accurately identifies and evaluates the potential effects of each alternative so that well-informed decisions regarding the consistency of the Resource Management Plans (RMP) with the Endangered Species Act and other applicable laws and policies can be made.

TU recently launched a coast-wide Wild Steelhead Initiative, which is designed to rebuild wild steelhead populations in rivers with high potential to support abundant, fishable wild steelhead populations. TU also recognizes that not all rivers that once supported wild steelhead have such potential due to severe habitat degradation, and that such systems

may be appropriate for steelhead hatcheries as a way to provide tribal and non-tribal fisheries. Reflecting our organizational emphasis on steelhead, our comments are focused on those aspects of the Hatchery DEIS pertaining to steelhead.

Before presenting commentary on specific issues, it is important briefly describe the current Puget Sound steelhead hatchery system and the purposes the hatcheries are intended to serve. Of the 23 steelhead hatchery programs in Puget Sound, only four have a conservation purpose; 19 are intended to produce fish for harvest (Table 2.2-3) using out-of-basin steelhead that originated in Chambers Creek (hereafter referred to as Chambers Creek stock). This means that only four of the programs have the potential to confer a recovery benefit to wild steelhead listed under the ESA. Based on the overwhelming scientific evidence regarding the effects of out-of-basin hatchery steelhead fish used to augment fisheries (e.g., Berejekian and Ford 2004; Chilcote et al. 2004, 2011; Kostow and Zhou 2006; RIST 2009), all such programs are negatively impacting wild steelhead, and the only question is the degree of harm.

Flaws in the Hatchery DEIS

1. <u>Aggregation of steelhead and salmon in alternatives analysis is contrary to NEPA's purpose because it hinders -- rather than enables -- informed decision-making regarding the effect of the RMPs on the productivity, abundance, diversity, and distribution of Puget Sound steelhead and their effect on potential steelhead fisheries.</u>

The fact that the Hatchery DEIS addresses RMPs that were first submitted to NOAA in 2004 makes commenting difficult due to major developments over the ensuing decade, not the least of which were the ESA-listing of the Puget Sound steelhead DPS (2007) and a wealth of new scientific research regarding the effects of hatchery steelhead on wild steelhead. Indeed, after NOAA issued the Hatchery DEIS, in November 2014 the co-managers submitted revised HGMPs for five winter steelhead hatchery programs. These revised HGMPs have not been evaluated in the Hatchery DEIS.

The decision to combine steelhead and all salmon species in a single EIS is problematic because steelhead differ from salmon in several important and consequential respects. First, they are trout, not salmon, and have significantly different life histories (Behnke 2002) and conservation needs (Busby et al. 1996). For example, unlike salmon, a significant portion of steelhead in any given population can spawn multiple times (Busby et al. 1996; Savvaitova et al. 2003). Second, steelhead, which are sea-run rainbow trout, mate (McMillan et al. 2007) and interbreed with resident rainbow trout populations (Seamons et al. 2004; Christie et al. 2011). As a result of these complexities steelhead display the most diverse set of life histories of any salmonid (up to 36 life histories: Thorpe 1998; Moore et al. 2014). Third, the diversity of steelhead (genetic, phenotypic, life-history), even more than for salmon, is key to maintaining productive wild populations because it helps buffer against environmental variability (e.g., Moore et al. 2014). Lastly, steelhead are particularly vulnerable to effects of hatchery practices (such

as selection for different growth rates: Reisinbichler et al. 1977) because they are one of the few species that require a prolonged rearing period (Berejekian and Ford 2004). As a result, hatcheries can dramatically simplify the natural life history diversity of steelhead (Tipping 1991), making the diverse wild steelhead particularly vulnerable to the deleterious effects of interbreeding with less diverse hatchery steelhead (Pearse et al. 2011).

There are also major differences in steelhead versus salmon fisheries. Unlike salmon, there are no commercial marine fisheries targeting steelhead. Also, there are no sport fisheries targeting steelhead in marine waters. Furthermore, most sport fishers targeting salmon prefer to kill and eat salmon – particularly chinook and coho – when regulations permit. In contrast, many steelhead anglers prefer to catch-and-release wild steelhead because they prize the opportunity to catch over the opportunity to harvest. This has significant socio-economic implications as discussed below.

These major differences are "washed out" in the Hatchery DEIS because the steelhead analysis is combined with the analysis of all salmon species. This renders the alternatives analysis inaccurate for steelhead, particularly conclusions regarding the likely effect of the alternatives on steelhead fisheries and socio-economic benefits and costs.

Due to the fact that there are five new HGMPs that were not analyzed in the Hatchery DEIS and the inaccuracies in the alternatives analysis resulting from both the aggregation of salmon and steelhead, we respectfully request that NOAA issue a supplemental DEIS addressing steelhead alone. A separate analysis that takes into account the unique biological needs of steelhead and the different socio-economics of steelhead fishing is essential to achieving NEPA's intended goal of promoting disclosue and analysis, and enabling informed decision-making.

2. <u>The Hatchery DEIS does not contain an adequate range of alternatives to fully and accurately analyze the likely effect on wild steelhead of different hatchery management options; one alternative that should be considered is the cessation of hatcheries in systems, such as the Skagit, with substantial wild steelhead populations and sufficient habitat to support wild fish.</u>

Analysis of alternatives is the "heart of the environmental impact statement." 40 C.F.R. § 1502.14. To that end, NEPA requires agencies to "[r]igorously explore and objectively evaluate all reasonable alternatives." *Id*. The "'existence of a viable but unexamined alternative renders an environmental impact statement inadequate.'" *Alaska Wilderness Recreation & Tourism Ass'n v. Morrison*, 67 F.3d 723, 729 (9th Cir. 1995).

The Hatchery DEIS fails to present and analyze an adequate range of reasonable alternatives. In fact, the alternatives considered are extremely limited. All alternatives assume continued operation of every existing steelhead hatchery, and all alternatives assume that the current purpose and operation of every steelhead hatchery remains the same. The result is only very minor differences among the alternatives due to changes in

only one variable – the number of juvenile fish released. Consequently, many other reasonable alternatives, including cessation of all isolated "harvest" steelhead hatcheries and conversion of isolated "harvest" hatcheries to integrated "conservation" hatcheries, are not rigorously explored and objectively evaluated as NEPA requires.

A specific alternative that should be considered in a supplemental DEIS is one that ceases steelhead hatchery operations in rivers, such as the Skagit, with substantial wild steelhead populations and sufficient habitat to support abundant, fishable wild steelhead populations, while using steelhead hatcheries to provide fisheries in river systems that, due to severe habitat degradation, no longer have potential to support fishable populations of wild steelhead. Such an alternative would appropriately take into account the major differences in habitat quantity and quality among Puget Sound rivers, and would better serve the goal of healthy, fishable and harvestable wild steelhead that is shared by tribal fishers and recreational anglers, and would be much more consistent with Washington's Statewide Steelhead Management Plan than any of the current alternatives presented.

Lastly, we disagree with NOAA's reasons for rejecting an alternative that would fully implement Hatchery Scientific Review Group's (HSRG) recommendations, which was an alternative requested during scoping of the DEIS. Such an alternative should be included because it is markedly different than the alternatives in the Hatchery DEIS and warrants consideration along with others to present a full range. The reason that NOAA gives for rejecting the option – that the co-managers are presently implementing all HSRG recommendations and will continue to do so through adaptive management therefore such an alternative need not be considered (p. 2-27) – is wrong for several reasons. First, the factual basis for the rejection is erroneous. Based on the record of implementation to date, correspondence with participants in the HSRG process, and the HSRG's recent report, *On the Science of Hatcheries: An updated perspective on the role of hatcheries in salmon and steelhead management in the Pacific Northwest* (October 2014), many of the recommendations are not being implemented by the co-managers and there is no basis for assuming that they will be in the future. Second, even assuming that the HSRG recommendations will be fully implemented, none of the Hatchery DEIS alternatives embody those changes and therefore they are not analyzed and cannot inform decision-making, which is the central purpose of an EIS.

For the reasons discussed above, the alternatives presented in the Hatchery DEIS fall far short of NEPA's requirement that a full range of alternatives be considered to enable informed decision-making. Accordingly, NOAA should issue a supplemental DEIS with additional alternatives, including those requested here, that present and analyze a full range of steelhead hatchery options.

3. <u>The Hatchery DEIS uses inaccurate and outdated scientific information regarding the effects of Puget Sound steelhead hatcheries on wild steelhead productivity, abundance, diversity and spatial distribution.</u>

The DEIS makes several statements that are contradicted by recent peer-reviewed scientific literature and evaluations of hatchery influences on wild steelhead.

a. The Hatchery DEIS inaccurately states that run-timing of segregated steelhead hatcheries prevents harm to wild winter steelhead (p. 3-166).

The above statement is not accurate for several reasons. First, there is overwhelming evidence that a substantial portion of wild steelhead historically entered rivers from late-November through January. Steelhead fishing seasons typically closed at the end of February in Washington State, and thousands of steelhead were caught annually in December and January, prior to the advent of Chambers Creek hatchery stock (Larson and Ward 1955; WDG 1956;Taylor 1979; McMillan 2008). In fact, estimates of steelhead catch in many of the streams were higher in December and January than they were in March (WDG 1956; Royal 1972; Taylor 1979). The historically earlier return timing would have provided substantial opportunities for wild steelhead to overlap and interact with Chambers Creek steelhead. Hence, present assumptions in the DEIS about run-timing differences between hatchery and wild steelhead are being made after decades of harvest fisheries, and potential interbreeding and competition with Chambers Creek steelhead.

Despite alterations to historic population attributes, Seamons et al. (2012) still found that using early-timed stock did not prevent interbreeding between wild and hatchery steelhead and that up to 80% of the offspring in a given year were from hatchery x wild matings. Recent observations in tributaries to the Skagit River also found substantial temporal overlap in spawn timing of hatchery Chambers Creek and wild steelhead (McMillan 2014). Such overlap likely explains the results of a recent report by Warheit (2014), which found substantial genetic interactions between hatchery (Skamania and Chambers Creek stocks) and wild steelhead in several Puget Sound streams. As a result the author concluded that segregated hatchery programs in the Green, Snohomish, Stillaguamish, Skagit, and Nooksack River basins have affected the genetic structure of the wild steelhead populations in those rivers. Although the Hatchery DEIS only considers hatchery winter steelhead, the results of Warheit (2014) suggest it is also necessary to include data on the effects of hatchery summer steelhead. Lastly, the Hatchery DEIS underestimates the harmful effect of hatchery steelhead on wild steelhead because most hybrids do not survive to adulthood (Chilcote et al. 1986; Leider et al. 1990), which means that the introgression measured in Warheit (2014) only considers the few that survived to become adults and does not account for all the other hybrids that perished as juveniles. In sum, the Puget Sound segregated steelhead hatcheries have had a profound negative impact on wild steelhead – particularly the historically large early-timed component of wild run.

Second, while run-timing is partly under genetic control (Hendry et al. 2002) and hatchery managers have attempted to select for early-timed adults in Chambers Creek stock, steelhead and rainbow trout of different life histories commonly give rise to alternatives (Kendall et al. 2014). Further, spawn timing is also influenced by water

temperature (Brannon et al. 2004) and relatively warmer or cooler thermal regimes could facilitate greater overlap between hatchery and wild steelhead. These factors could help explain why spawning hatchery and wild steelhead overlapped in Seamons et al. (2012) and McMillan (2014).

Third, a proportion of hatchery smolts never migrate to the ocean and instead remain in freshwater as residents or "residuals" (McMichael et al. 2000). Residency is more common in males than females (Rundio et al. 2012) and hatchery steelhead are known to produce mature residual males (hereafter referred to as precocious males: Schmidt and House 1979; Tipping et al. 2003). Precocious hatchery males are released into the river during or near the peak spawn time for wild steelhead and have been observed spawning with wild female steelhead (McMillan et al. 2007). Thus, selection for timing of return by adult steelhead does not eliminate precocial males with different spawn timing, indicating the potential spawn timing for Chambers Creek steelhead is broader than stated in the Hatchery DEIS. Considering that 2.5 million steelhead are released annually into Puget Sound streams, even a small percentage of residual males could represent a substantial portion of male mates in the wild populations.

Fourth, the return timing does not eliminate potential effects of competition and predation between wild and hatchery smolts, which is acknowledged by NOAA in the Hatchery DEIS. Importantly however, just because a Chambers Creek steelhead may spawn earlier than a wild steelhead does eliminate effects later in the life cycle. In fact, it may exacerbate them. For example, offspring from salmonids that spawn earlier in the season are typically larger entering their first summer than those offspring from adults that spawned later in the year because they had greater time for growth (Groot and Margolis 1991; Quinn 2005). We assume, then, that offspring from Chambers Creek steelhead are likely to be larger in size early in summer because they emerge earlier than offspring from the proportion of the wild steelhead population that spawns later in the spring (Noble 1991). The larger size provides competitive benefits to hatchery fry, which can displace or dominate smaller wild individuals and ultimately influence the distribution and growth of wild fry (Noble 1991).

b. The Hatchery DEIS inaccurately states that life history attributes and distribution of natural-origin steelhead are not influenced by releases of hatchery steelhead (p. 4-438-39).

As just discussed, there was a large early-timed component of wild steelhead in November, December and January in Puget Sound prior to the advent of the Chambers Creek hatchery stock (Larson and Ward 1955; Taylor 1979). And, there is currently more extensive overlap in spawn timing of Chambers Creek and wild steelhead than is acknowledged in the draft Hatchery DEIS (e.g., McMillan 2008, 2014). Thus, interbreeding between Chambers Creek stock and wild steelhead, as well as the harvest of wild steelhead in fisheries targeting hatchery fish, has already strongly altered the run-timing of wild steelhead in Puget Sound (e.g., McMillan 2008), which is a critical aspect

of life history diversity. Additionally, interbreeding and competition with Chambers Creek steelhead has the potential to influence the spatial distribution of wild steelhead (e.g., Pearse et al. 2011) in locations where they spawn at similar times, which appears more common (e.g., Seamons et al. 2012; McMillan 2014) than the Hatchery DEIS suggests. Consequently, we strongly disagree that Chambers Creek steelhead have not and do not have the capacity to deleteriously influence life history diversity and distribution of wild steelhead. In fact, the overwhelming evidence suggests that deleterious effects are substantial and pervasive.

Changes to life history diversity and distribution have important implications for the future viability of wild steelhead in Puget Sound. Indeed, the Hatchery DEIS states that life history differences within and among steelhead in the river basins represent the genetic and behavioral diversity that allows the species to adapt to short-term and long-term habitat changes over time (p. 4-438). As an example, shifts in stream temperature and flow regimes related to climate change pose threats to wild steelhead (Waples et al. 2009), particularly in Puget Sound due to factors such as increased high flows during spawning and decreased summer low flows during rearing (Wade et al. 2009). Steelhead display remarkable plasticity and their life histories can change with a changing environment, but only if they have a full reservoir of genetic and phenotypic diversity to draw upon (Moore et al. 2014; Kendall et al. 2014). Earlier spawning may be part of the solution for wild steelhead persistence as it is now in warmer climates of coastal Oregon and northern California (Busby et al. 1996). It would provide juvenile fish the benefit of earlier emergence and greater growth entering summer, which will be critical to maintaining an evolutionary pace with the earlier onset and greater duration of summer low flows. This will not be possible however if the genetic and phenotypic diversity of steelhead continues to be limited and constrained by the early-timed Chambers Creek stock.

4. <u>The Hatchery DEIS analysis of the potential effects of changes in hatchery management on steelhead fisheries is based on outdated and inaccurate information, and fails entirely to consider catch and release fishing opportunity and its socio-economic benefits.</u>

The analysis of the socio-economic impacts of the alternatives with regard to steelhead fisheries is deeply flawed for several reasons and must be remedied in a supplemental DEIS.

a. The aggregation of salmon and steelhead fisheries results in a highly biased and inaccurate analysis of the socio-economic effects of changes in steelhead fisheries under each alternative.

As discussed above, the draft Hatchery DEIS inappropriately aggregates all salmon species and steelhead in its alternatives analysis. Nowhere are the problems with this "lumping" more pronounced than in the socio-economic analysis. By far the biggest

problem is that salmon and steelhead fisheries are very different in terms of location, size, purpose and gear. Two major differences include: (1) steelhead are not commercially or recreationally harvested in the marine environment; (2) commercial harvest of steelhead is limited to in-river tribal fisheries.

These major differences are simply lost in the Hatchery DEIS because of the aggregated analysis of salmon and steelhead in the four alternatives. The practical effect of this aggregation is to imply significant negative socio-economic effects of the reduction in hatchery production of steelhead called for in Alternative 3, and, conversely, to imply that Alternative 4 would have substantial socio-economic benefits related to steelhead fisheries. (Tables 4.3-6, 4.3-7). Neither of these implications is accurate. This thwarts, not enables, informed decision-making.

Table 3.3-3 shows just how minor the economic benefits of the commercial steelhead fishery is today and would be under any of the analyzed alternatives. The total number of fish caught annually projected to be between 600 and 810 fish under the four alternatives, with an economic value of only between $4,400 and $5,600. In contrast, the commercial salmon fisheries are many orders of magnitude larger. And, of course, when the cost of producing these hatchery fish is factored into the analysis, the cost of producing wild steelhead far exceeds their commercial value.[1]

b. The method chosen for valuing recreational fisheries in the Hatchery DEIS fails entirely to account for catch-and-release fisheries focused on wild steelhead and the socio-economic benefits they provide, while also vastly inflating the contribution of the extant steelhead hatchery programs to recreational opportunity and socio-economic benefits.

Appendix 6 to the Hatchery DEIS describes the methods used to estimate the economic value of recreational fisheries in Puget Sound. The particular methodology used was to look at harvest data to estimate angler trips, and then monetize the value of those trips. (p. I-8) The major flaw in this approach is that it completely ignores catch-and-release fisheries,[2] which are highly popular and are focused on wild steelhead, not hatchery fish.

The effect of this lopsided analysis is to vastly over-value steelhead harvest fisheries provided by the current hatchery system, and, in turn, the importance of hatcheries to

[1] The Hatchery DEIS does not provide monetary estimates of the value of recreational steelhead fisheries in Puget Sound. Instead, all that is presented is aggregated information (Tables 4.3-4, 4.3-5). Thus, it is not possible to identify the economic value of recreational steelhead fisheries alone based on the information presented.

[2] Federal policy expressly promotes the use of catch-and-release fisheries as a way of providing fishing opportunity while ensuring the conservation of fish resources. Specifically, the Magnuson Stevens Act states that recreational fisheries should be managed "under sound conservation and management principles, including the promotion of catch and release programs in recreational fishing." (16 U.S.C. Section 1801(b)(3)).

providing fishing opportunity. The problem goes even deeper, however, because, as we have presented, the widespread use of isolated harvest hatcheries with Chambers Creek stock has been a major factor in the decline of wild steelhead populations on rivers like the Skagit and Snohomish, through interbreeding and competition with wild fish, as well as through mixed-stock harvest fisheries focused on hatchery fish that took a heavy toll on early-timed wild steelhead.

The decline of wild steelhead steelhead has led to severe restrictions on catch-and-release fisheries which, in turn, has resulted in major losses in recreational steelhead fishing opportunity and the substantial socio-economic benefits those fisheries provide. Indeed, it is highly probable that, in river systems like the Skagit and Snohomish, the cessation of problematic isolated hatcheries and harvest fisheries targeting hatchery fish would enable wild steelhead abundance to increase (e.g., Chilcote et al. 2004, 2011; Kostow and Zhou 2006) and thus provide more fishing opportunity and economic benefit than status quo management. Evidence of this can be found in the Skagit, where, as the number of Chambers Creek hatchery plants have decreased, wild steelhead abundance has swelled to over 9,000 fish – 3,000 over the escapement goal. In fact, analysis by Ruff et al. (2014) found a statistically significant negative relationship between the number of hatchery fish released and wild steelhead productivity in the Skagit River, and urged careful consideration of hatchery policy. Given that such a pattern exists in the Skagit River it is probably that wild steelhead could respond similarly in other rivers with adequate habitat.

The flaw of viewing fishing opportunity as contingent on harvest opportunity also results in inaccurate conclusions regarding the importance of steelhead hatcheries to fishing opportunity. Specifically, the the Hatchery DEIS describes the potential effect of reductions in hatchery steelhead releases under Alternative 3 as likely to result in a "major" reduction in recreational fishing opportunity in many Puget Sound. (Table 4.3-10). This erroneous conclusion is stated multiple times at various points throughout the DEIS (e.g., 4-114 (statement that steelhead fishing trips would decrease if hatchery production decreased); 4-144 (statement that North Sound steelhead fisheries are "enhanced" by hatcheries; 5-17 (same)). This conclusion is flawed in two respects. First, it assumes that there will be no catch-and-release steelhead fisheries providing recreational opportunity. Second, it reflects an inaccurate, overly optimistic view of of the contribution of isolated hatcheries to fisheries.

Far from providing a lot of angler opportunity, the fact is that hatchery steelhead adult returns are typically low providing little in the way of quality fishing opportunity in Puget Sound rivers. The Hatchery DEIS acknowledges that the overall total return benefit is low, largely because smolt-to-adult survival rates for the Chambers Creek stock are generally one percent or less (3.2.7.4.5). This is well below the survival rate goal of 5% for hatchery steelhead (Table B-8). This raises the question of whether the small number of adults provides any real benefits, particularly considering the risks to wild steelhead and the frequent recreational fishing closures. For example, the recreational steelhead fishery was closed in the Nooksack River this year due to low hatchery adult returns. In addition, attached to this comment letter is a graph of adult returns of hatchery and wild

steelhead in the Skagit River plotted against releases of hatchery juveniles, which clearly shows that adult returns are inversely related to hatchery plants. Indeed, Ruff et al. (2014) quantified this relationship and found that the return of wild adult steelhead in the Skagit River was negatively associated with increasing hatchery smolt plants. This suggests that the segregated hatchery program has actually reduced fishing opportunity on the Skagit, and it certainly has not improved it.

In summary, the central problem with NOAA's analysis of recreational steelhead fisheries is that the analytical construct is deeply flawed. By looking exclusively at how existing harvest fisheries based on segregated hatchery programs are affected by increases or decreases in hatchery production at those facilities, the conclusion is pre-determined: reductions in hatchery releases will reduce <u>that</u> opportunity. By conducting such a narrow analysis, NOAA utterly fails to take the required hard look at how the full range of recreational steelhead fisheries have been impacted by the existing hatchery system and would likely be impacted under the alternatives considered. Indeed, the evidence strongly indicates that the isolated steelhead hatcheries have had a negative impact on catch-and-release recreational angling opportunity with substantial negative socio-economic consequences. Accordingly, NOAA, consistent with the policy and requirements set forth in the Magnuson Stevens Act, needs to make a much more comprehensive and better substantiated analysis of recreational steelhead fishing and related socio-economic benefits in a supplemental EIS to meet NEPA requirements.

5. <u>The Hatchery DEIS fails entirely to address the effects of mixed-stock steelhead fisheries on wild steelhead.</u>

As discussed previously, a major shortcoming in the Hatchery DEIS is the failure to acknowledge the importance of the early-timed portion of the wild steelhead run to the health of Puget Sound wild steelhead populations and the impact the isolated hatcheries have had on early-timed wild fish. In fact, as mentioned earlier, the Hatchery DEIS explicitly -- and erroneously -- states that the early run timing of the Chambers Creek stock used in the isolated hatcheries prevents harm to wild winter steelhead because they are temporally segregated. (3.3.26). Historic records show clearly that there was a major early-timed component of wild steelhead in Puget Sound river systems, including the Skagit and Snohomish, proving false the assertion of temporal segregation (WDG 1956;Taylor 1979; McMillan 2008). In fact, for Puget Sound Larson and Ward (1954) found that over 80% of the steelhead catch in 1953 was between December and February and that the percentage of total catch per month was 27.7% in December, 21.0% in January, 31.7% in February, 18.2% in March, and 1.4% during April. There is also evidence that strong selection for early-timed breeding in Chambers Creek stock cannot enitrely eliminate interbreeding with wild steelhead and that levels of interbreeding can be quite high in some years (Seamons et al. 2012). This means that there has likely been high potential for competition and mating since the Chambers Creek stock was initially planted in Puget Sound River over 60 years ago.

The failure to recognize the existence, let alone significance, of the early-timed portion of Puget Sound wild steelhead populations, is a serious flaw in the Hatchery DEIS. Further, the scientific research that has come to light since the RMPs were first submitted to NOAA in 2004 clearly establishes the importance of life-history diversity to abundant, productive and resilient populations (Christie et al. 2011; Moore et al. 2014). Given that the purpose of preparing the EIS is "to ensure the sustainability and recovery of Puget Sound salmon and steelhead by conserving the productivity, abundance, diversity and distribution of listed species of salmon and steelhead in Puget Sound," (S-4, emphasis added) the state of the early-timed portion of the run is a highly relevant issue.

The evidence clearly indicates that isolated steelhead hatcheries have harmed wild steelhead, particularly the early-timed portion of the run through mixed-stock harvest fisheries targeting hatchery steelhead produced at the isolated facilities. The harvest data for rivers like the Skagit shows that for many years there was intensive harvest of hatchery and wild steelhead in the early winter when hatchery fish were returning (WDG 1956; Taylor 1979). These high harvest rates ultimately fell dramatically as the abundance of both wild and hatchery adults dropped precipitously. The Hatchery DEIS is completely silent on this issue, and NOAA needs to address it fully in a supplemental DEIS because the early-timed component of the population may be particularly important to rebuilding and sustaining wild steelhead in light of climate change and increased human population in Puget Sound.

6. The Hatchery DEIS fails to address how hatchery operations impact the large investments being made in Puget Sound habitat restoration, in particular whether hatcheries are reducing the benefits of habitat restoration for ESA-listed stocks and the return on those habitat investments to taxpayers.

Over the past decade, hundreds of millions of taxpayer dollars have been spent to restore salmon and steelhead habitat in Puget Sound to recover ESA-listed salmon and steelhead. TU supports these investments, which are necessary to restore the processes and structure of Puget Sound rivers that enable wild fish to flourish.

Of course, restored habitat itself does not produce more wild fish. Wild fish using that habitat increases the abundance, productivity, diversity and spatial distribution of wild fish. Thus, if taxpayers are to realize the full value of their habitat restoration investments, we must ensure that our hatchery practices do not significantly impair the ability of wild fish to use the productive capacity of the habitat we are working very hard to restore. This point was emphasized by the Hatchery Scientific Review Group in its recent report, *On the Science of Hatcheries: An updated perspective on the role of hatcheries in salmon and steelhead management in the Pacific Northwest* (October 2014).

The Hatchery DEIS is completely silent on this topic. With regard to steelhead hatcheries, 19 of the 23 are operated to provide harvest opportunity using out-of-basin

Chambers Creek stock, as opposed to serving a conservation purpose. Scientific research has shown quite clearly that non-native hatchery stock survive at substantially lower rates than wild fish (Chilcote et al. 1986; Leider et al. 1990; Hulett et al. 1994; McLean et al. 2003, 2004; Araki et al. 2007). As a result, interactions with hatchery fish may impair and depress productivity of wild populations through various mechanisms (Chilcote et al. 2004, 2011; Kostow and Zhou 2006; Ruff et al. 2014), including genetic introgression (Pearse et al. 2011) and competition (Kostow and Zhou 2006).

So, for example, if a significant amount of new spawning habitat is opened up through habitat investments, to get the full benefit of those investments that habitat should be used by wild fish so that the offspring are fit and likely to survive and return as adults. If, however, a significant percentage of the spawners using that habitat are hatchery fish, the reproductive success of the spawners using that habitat will be significantly lower (Chilcote et al. 2004, 2011) because hatchery x wild hybrids have lower fitness (Araki et al. 2007) and, to the extent hatchery fish are interbreeding with wild fish, the genetic integrity of the wild population will be diluted (Pearse et al. 2011). The negative effects are carried through future generations reducing viability of the population (Goodman 2005), thereby impeding or preventing recovery (RIST 2009)

If those of us who care about the health of rivers and wild fish want to see public investments in habitat restoration continue – and that is all stakeholders, then we must demonstrate that hatchery and harvest actions are not undermining those investments. Indeed, NOAA has a legal mandate under the ESA to ensure that actions, such as the RMPs that are the subject of the Hatchery DEIS, not only do not result in extinction, but that they also are consistent with recovery of listed fish. This issue must be addressed in a supplemental DEIS.[3]

7. <u>The Hatchery DEIS fails to identify or analyze the cost of producing steelhead at Puget Sound hatcheries, which precludes a cost-benefit analysis that is essential for informed decision-making.</u>

Lastly, the socio-economic analysis lacks a cost-benefit analysis that is necessary to provide decision-makers with an understanding of the economic efficiency of hatchery operations. In particular, NOAA should calculate the cost of producing an adult hatchery steelhead at Puget Sound hatchery facilities. This information is important because it will reveal how effective license-holder and taxpayer investments in hatcheries are with respect to meeting their intended purpose. For 19 of the 23 steelhead hatcheries, that purpose is fish for harvest.

[3] We recognize that it probably is not possible to quantify the impacts of isolated steelhead hatchery operations on the efficacy of habitat restoration investments, but it certainly is possible to express qualitatively such impact based on peer-reviewed scientific literature. This information should be included in a supplemental DEIS.

Given the poor performance of isolated hatcheries in producing steelhead for harvest, such an analysis will almost certainly show that isolated steelhead hatcheries are not cost effective. When this information is coupled with the following facts: (1) that the fish produced in isolated hatcheries harm wild steelhead; (2) that the commercial value of harvested steelhead is projected to be less than $10,000 annually under all alternatives; and (3) that harvest is not necessary to realize major socio-economic benefits from recreational fishing opportunities -- none of the four alternatives analyzed in the Hatchery DEIS look appealing.

Conclusion

For all of the reasons explained in detail above, the draft Hatchery DEIS needs considerable improvements before it is consistent with NEPA requirements and will enable informed decision-making. In light of the depth and breadth of the flaws in the draft Hatchery DEIS, the appropriate course is for NOAA to issue a supplemental DEIS rectifying the numerous shortcomings.

A supplemental EIS must be prepared when necessary to serve the dual purposes of NEPA: "to assure that the public who might be affected by the proposed project be fully informed of the proposal, [and] its impacts…; and to give the agency the benefit of informed comments and suggestions as it takes a 'hard look' at the consequences of proposed actions." *Dubois v. U.S. Dep't of Agric.*102 F.3d 1273, 1291 (1st Cir. 1996).

With the the future of wild steelhead and steelhead fishing opportunity at stake, as well as the success of the public's enormous investment in Puget Sound habitat restoration, it is imperative that NOAA analyze a full range of reasonable alternatives using an approach that illuminates -- rather than obscures -- the effects of Puget Sound steelhead hatcheries, and that it utilize the best available scientific and economic information in conducting its analysis.

Thank you for your consideration.

Sincerely,

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Citations

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ATTACHMENT E

The Reproductive Ecology of *Oncorhynchus mykiss*
in Tributary Streams of the Mid Skagit River Basin

Bill McMillan, (DRAFT as of January 15, 2015)

Photo 1: Skagit River Sexually Mature Wild Steelhead of 19 lbs 10 oz Caught January 25, 1959

Introduction

The Skagit River is the largest river basin of Washington's Puget Sound. The Mid Skagit River basin for purposes of this report is considered to be the 43 mile (67.6 km) length of the mainstem Skagit and smaller tributaries from the town of Sedro-Woolley (~RM 24) to the entry of the Sauk River (RM 67). At the time of 1895 the Skagit basin had an estimated mean return of over 105,000 wild steelhead (Gayeski et al. 2011). Current wild steelhead returns (2002-2011) are 5-6% of historic levels (Appendix C of McMillan 2012). Wild steelhead harvest alone from 1961-62 through 1965-66 was an average of nearly 13,000, and wild harvest as late as 1974-75 was over 15,000 (Phillips et al. 1981b; and Appendix E). As of 2007, Puget Sound (including the Skagit basin) steelhead have been listed as Threatened under the Endangered Species Act (ESA) (NMFS 2007).

Oncorhynchus mykiss (*O. mykiss* hereafter) is noted for great breadth of life history diversity and unusual plasticity among Pacific salmon species with the most southern range extent (Shapovalov and Taft 1954; Augerot 2005). Wild winter steelhead spawning time in western Washington has been documented as January to June-July by Washington Department of Natural Resources (WDNR) and through independent surveys by the Wild Salmon Center (WSC) (Cederholm 1984; McMillan 2007). The earliest description related to the reproductive ecology of the anadromous life history of *O. mykiss* in Mid Skagit River tributary streams is that of a U.S. Fish Commission egg-taking operation at Finney Creek in 1901 (Ravenel 1902):

Page 84: *"Early in March it was decided to again attempt the collection of eggs of the steelhead trout ... Phinney Creek ... was selected ... and by the middle of the month a rack was completed and net fishing*

commenced under the direction of Mr. Henry O'Malley. Only a few fish were caught, and it soon became evident that the run of steelheads was over. Exploration on Phinney Creek, Grandy Creek, and the Skagit River did not show any large numbers, all testimony seeming to prove that the principal run had gone up in January."

The indicated steelhead migration into Finney Creek prior to mid March, and principally in January, would be necessary to result in the initiation of steelhead spawning at the Sauk River of the Skagit basin reported by the Washington Fish Commissioner (Riseland 1907):

Page 23: *"The steelhead spawn from the first part of February until the 15th of June."*

The breadth of entry time of steelhead to the Skagit River in 1895, the earliest year of commercial catch record in the basin, was described in a U.S. Fish Commission report (Wilcox 1898):

Page 595: *"The several species of salmon and seasons when found are as follows: ... steelhead, from November 15 up to the following spring ..."*

The wild winter steelhead that reproduced in the Skagit basin near their peak historic abundance thought to end about 1895 (Gayeski et al. 2011) had migrations that commenced Skagit River entry in mid November with a major upstream migration in January, and included entry to Finney and Grandy creeks of the Mid Skagit basin. In the case of Finney Creek, steelhead spawning entry was nearly over by mid March. Although spawning time in Finney Creek (RM 47.5) was not mentioned, steelhead likely began spawning at least by early February and ended by mid June as described in 1907 for the Sauk River (RM 67.2) just upstream of the Suiattle River (RM 13.2), likely near today's Hatchery Creek (RM 13.4). This Sauk River location is 32 miles upstream from Finney Creek with an elevation gain of about 242 ft. Photo 1 depicts a wild steelhead in mature male spawning coloration taken near Rockport, WA on the Skagit River on January 25, 1959 by Russ Willis (Western Washington University, Bellingham, WA, 6th Floor of the Wilson Library, in the Heritage Resources, Fly Fishing Collections; additional information pers. com. Danny Beatty, Anacortes, WA who acquired it for the Collections). The 1959 steelhead exhibits the historic attributes earlier described in Skagit basin steelhead.

Between 1914 and 1920 steelhead egg-taking operations for hatchery rearing were recorded at three Skagit River tributary streams (Smith and Anderson 1921 in Table 1, Appendix B). Weirs are difficult to maintain during higher flow events and even today significant escapement of steelhead occurs around weirs (Seamons et al. 2012) despite easier access to weir sites and improved technology since the early 1900s. As a result, the early egg taking operations at Day and Illabot creeks may not have well represented actual return numbers of female steelhead and would be a minimal count. Grandy Creek was the central location at that time, however, for hatchery operations in the Skagit basin (Smith and Anderson 1921) and likely had a more efficient weir. Using the average number of eggs taken per female steelhead from Green River tributary streams between 1939 and 1941 (Pautzke and Meigs 1941), at Grandy Creek the number of female steelhead stripped of eggs ranged from 79 to 1,125 per year; at Day Creek from 29 to 100; and at Illabot Creek from 21 to 158. Even at minimal female numbers represented, it is apparent that Skagit River tributary streams supported considerable steelhead spawning at a date when overall salmon and steelhead numbers were described as already greatly depleted from former times (Smith and Anderson 1921).

As a result of the 1974 Boldt court decision and the subsequent steelhead management changes that occurred in the Boldt Case Area of Washington (Puget Sound and the Northwest Coast) thereafter, data began to be collected from which to manage for a 50% division of harvest between tribal and sport fisheries and eventual

determination of spawning escapements (Cohen 1986). In the case of the Skagit River basin, spawning survey data are available from 1978 to 1981, a time period when 65%-80% of steelhead spawning found was in the tributary creeks (Phillips et al. 1981b). The available evidence indicates that Skagit River tributary streams were historically vital to overall steelhead productivity, and included those of the Mid Skagit basin.

A basic Skagit River steelhead management assumption by Washington Department of Fish and Wildlife (WDFW) has been (WDFW 2004):

Page 118: "*Wild origin winter steelhead have been defined as those fish that spawn after March 15...* (and) *steelhead of hatchery origin that spawn in the wild are defined as those fish spawning before March 15, for management purposes on the Skagit (Woodin et al. 1984)."*

As a result, WDFW steelhead spawning surveys in the Skagit basin have commonly been initiated about March 15th in the assumption that wild steelhead do not spawn prior to that date. In the Skagit basin it was indicated in the same WDFW document:

Page 141: *"... introgression between hatchery and wild fish ... is believed to be low as there is currently substantial temporal separation of hatchery and wild spawn timings, and spawning overlap is believed to be less than 1% (C. Kraemer, WDFW, pers. comm., 12/12/03)."*

Page 142: *"The section of the Skagit River that has been the most heavily spawned by hatchery-origin adults is the area upstream of Grandy Creek between the Cascade and the Sauk rivers..."*

However, the above management assumptions have been largely made with an absence of spawning surveys that could actually document how much hatchery and wild spawning occurs in the Skagit basin prior to March 15th, and where it occurs. Oregon has developed a more thorough ground-truthed approach for monitoring steelhead of its Coastal streams (from Susac and Jacobs 1999):

Page 2: *"The percentage of hatchery origin steelhead spawning naturally in the wild poses a great deal of concern to fisheries managers. The Oregon Wild Fish Management Policy (OAR 635-07-525) sets guidelines as to the percentage of stray hatchery fish permitted to spawn naturally in individual basins and subbasins. It is important for fisheries managers to know the percentage of hatchery strays spawning naturally in the wild. Currently, all of the hatchery origin steelhead released in Oregon and destined to return as adults in 1998 are marked with an adipose fin-clip. We have started to evaluate the feasibility of using visual detection of marked and unmarked adults on the spawning beds to determine hatchery:wild ratios."*

Page 2: *" ... 1) steelhead spend only a short time on spawning beds, 2) fish not actively spawning are elusive, and 3) hard to count and steelhead do not necessarily die after spawning. In addition to difficulties associated with their behavior in spawning streams, the extensive temporal and spatial spawning patterns exhibited by coastal winter steelhead stocks create challenging survey conditions. The spawning season is generally quite protracted, lasting up to 6 months..."*

As a result there are no assumptions about hatchery and wild steelhead spawning that exclude any part of the potential spawning season as monitored in spawning surveys in Oregon:

Page 10: *"Surveys were conducted from mid January to mid May.*

Regarding steelhead spawning further north, winter steelhead spawning was documented to begin on central Vancouver Island's Cowichan River by January in the 1940s (Neave 1949), and in the 1980s was found to begin in January-February at the Queen Charlotte Islands (de Leeuw and Whately 1983; de Leeuw 1984; 1985; 1986; and 1987). At the Situk River of Southeast Alaska, steelhead spawning has initiated as early as February (Johnson 1991).

On becoming a resident of the Mid Skagit basin in 1998, it became of increasing interest what salmonid spawning was occurring at a number of local tributary streams. With a history of doing volunteer spawning surveys as a hobby biologist from 1979 to 1996 on Lower Columbia River streams, and professionally from 1997 to 1998 in the Snohomish basin and from 2000 to 2006 in the urban creeks of King County, the Mid Skagit tributary streams provided near-by interest due to differences in their hydrologic regimes, stream channel characteristics, and directional aspects to the sun. On retirement at the end of 2006 as a professional field biologist for a non-profit fish conservation organization, I had time to consider surveying streams again in the freedom of volunteerism as a hobby biologist.

I first came to familiarize myself with these streams and others in the Skagit basin through angling on moving to the Skagit Valley in 1998. It provided a means to determine *O. mykiss* and *O. clarki* species presence, potential fish passage barriers that may isolate them from each other, or overlaps within each stream that may otherwise occur. However, my commitment to doing regular surveys did not more consistently occur until the fall of 2009 and spring of 2010. These surveys continued to regularly occur through the spring of 2014 during the salmon and steelhead spawning periods at O'Toole, Mill, Savage, and Finney creeks, and at Dry Creek (tributary of lower Finney Creek) in 2013 and 2014. From October 3, 2013 through June 16, 2014 the surveys made at these five Mid Skagit tributaries were made with greater frequency compared to other years with particular intent to increase observations of active steelhead spawning if possible. Surveys were also made intermittently at several other Mid Skagit tributaries during the anticipated steelhead spawning period. The overall goal of the spawner surveys was to gain an understanding of the steelhead which spawn in these streams and to determine the following:

1) earliest and latest steelhead spawning by tributary
2) total steelhead spawning redds by tributary, or tributary reach surveyed
3) hatchery and wild steelhead during active spawning
4) the proportion of steelhead spawning before and after March 15th
5) *O. mykiss* life history mixes (i.e. anadromous and resident) during active spawning
6) steelhead spawn time differences between differing tributaries
7) environmental factors that may determine steelhead spawning time differences by tributary
8) steelhead spawn time overlaps with other salmonids
9) *O. mykiss* fry emergence dates

Determination of spawning prior to mid-March and potential overlaps between wild and hatchery *O. mykiss* were priority objectives due to the lack of historical spawning surveys that could document this in tributary streams of the Skagit basin (or elsewhere in most of Puget Sound and much of western Washington). Although *O. mykiss* reproductive ecology in these tributaries is the focus of this report, the surveys included a complete record of all salmonid spawning found from the beginning of the first autumn storm events that provided anadromous fish access into these tributary streams. In this way it was possible to ensure that the earliest *O. mykiss* spawning was found and how the timing of one species may overlap with another in the need to separately identify their redds based on differing redd characteristics. A further purpose for this report is to

stimulate data collection that over time can result in a broader understanding of the complexity of *O. mykiss* life history diversity necessary for productivity across a broad range of available habitats and to provide an improved template for future monitoring of steelhead in the Skagit basin that can more effectively guide management for wild recovery through a future predicted to include increasing climate change.

Methods

Streams Surveyed

Mid Skagit basin tributary streams were chosen for spawning surveys due to proximity to my place of residence at RM ~46 near the mouth of Savage Creek and from which daily weather and stream flow conditions could be quickly determined. Five of these streams are publicly accessible by walking for their entire anadromous length and met the criteria for either determining a good approximation of the total spawning use by each salmonid species, or a sufficiently long and typical stream reach from which a significant proportion of the spawning by each species could be determined. Table 1 provides the five main streams and 2013-2014 survey lengths; Table 2 provides streams intermittently surveyed. The stream lengths were determined by Google Earth measures in yards (yds) and kilometers (km). Table 2 of Appendix F provides the dates of each 2014 survey from January 1st through June 16th (and other information).

Table 1. Mid Skagit tributary creeks regularly surveyed in 2013-14

Tributary	Anadromous length	Length surveyed	Begin rkm	End rkm	Number of surveys	First survey	Last survey
Finney Ck	20,678 yds 18.908 km	3,825 yds 3.498 km	1.87	5.37	10	2-2-2014	5-30-2014
Dry Ck of Finney Ck	950 yds 0.869 km	950 yds 0.869 km	0	0.87	26	11-6-2013	5-30-2014
Savage Ck	>4,409 yds >4.032 km	4,409 yds 4.032 km	0	4.03	45	10-3-2013	5-6-2014
Mill Ck	1,850 yds 1.692 km	900 yds 0.823 km	0	0.82	29	10-3-2013	5-22-2014
O'Toole Ck	680 yds 0.622 km	680 yds 0.622 km	0	0.62	10	10-4-2013	6-16-2014

Table 2. Mid Skagit tributary creeks intermittently surveyed in 2013-14

Tributary	Anadromous length	Length surveyed	Begin rkm	End rkm	Number of surveys	First survey	Last survey
Quartz Ck of Finney Ck	Unknown	160 yds 0.146 km	0.34	0.49	1	5-16-2014	5-16-2014
Hatchery Ck of Finney Ck	>570 yds; 0.521 km	400 yds 0.366 km	0	0.37	2	3-23-2014	5-6-2014
Grandy Ck	7,950 yds; 7.269 km	2,000 yds 1.829 km	0.30	1.71.	1	2-20-2014	2-20-2014
Cumberland Ck	1,300 yds; 1.189 km	577 yds 0.528 km	0.25	0.78	1	5-2-2014	5-2-2014

Breadth of Time Period for Surveys

To assure that no atypically early steelhead spawning went unrecorded, the 2013/2014 Mid Skagit tributary

surveys began with the first series of storms that recharged the tributary streams in the fall to facilitate anadromous fish passage into them. This occurred early with over 12 inches (30.5 cm) of rain recorded in the Mid Skagit basin in September, the largest amount since I began recording September rainfall in the area in 2002 (Appendix A.). Surveys began in early October but missed the first few days of salmon spawning activity that likely occurred in Finney, Mill, and O'Toole creeks, but redds and carcasses remained to provide good counts of spawning that likely occurred.

In the case of Finney Creek, fall spawning surveys did not occur in 2013 due to the stream conditions often being too discolored to do so, but also because surveys in prior years had already indicated what spawning use occurs there prior to the initiation of steelhead spawning in winter. It was hoped that surveys targeting steelhead could begin in January of 2014, but water conditions were unfavorable to do so until February. At Finney Creek water conditions absolutely dictate survey times which can't be predetermined. Some years there may be too little survey time to provide useful information. This was not entirely the case in 2014 for steelhead at Finney Creek, but as previously indicated, some spawning in January and February may have been missed due to turbidity and this continued through March.

In the case of Dry Creek of lower Finney Creek, entry of pink salmon was not anticipated due to its small size and common dewatering. It was thought to be the last of local Mid Skagit tributary streams to recharge with fall rains and perhaps too little flow to coincide with pink salmon spawning use potential. However, when surveys began there in early November, at the end of anticipated pink salmon spawning, considerable prior use by pink salmon was found and future surveys will be adjusted accordingly.

The surveys remained sustained until the final spawning by steelhead was thought to be found. In most cases this was early to late May, but in the case of O'Toole Creek it had previously been noted that particularly late spawning can occur and a final survey there was made in mid-June. There was also a gap in surveys at O'Toole from November 12th of 2013 until March 12th of 2014. Past surveys of O'Toole Creek have found minimal coho spawning there and chum spawning is typically contained to October. Only twice was early steelhead spawning found there, in both instances near where it joins the Skagit River which may have included river backflow into it. It is one of the coldest streams as previously found and has a substrate where redds can remain visible for considerable time. Because it is somewhat out of the way geographically from the other streams regularly surveyed, it was the choice to exclude during a time period when the other streams were more anticipated to have spawning occurring. It was a choice of where available time was best spent.

My surveys were predicated on historic information that identified Puget Sound historic wild steelhead spawning began in January (Evermann and Meek 1898) and/or February (WDG 1931-1940). In the Skagit basin, Finney Creek steelhead entry for spawning was primarily in January (Ravenel 1902) and steelhead spawning began by at least early February in the Sauk River (Riseland 1907). I anticipated that January and February spawning still occurs and should guide present wild steelhead monitoring. Chambers Creek origin hatchery steelhead, as have been long planted in the Skagit basin, are also known to spawn by December and January and continue into March (Crawford 1979). Their extent of spawning can continue as late as April 27th as found at the Kalama River of the Lower Columbia (Crawford et al. 1978). My prior survey experience in the Mid Skagit basin tributaries found that steelhead do begin spawning in January and this continued to guide the decision to begin spawn surveys by that time in 2014.

Survey Frequency and Timing of Individual Surveys

The frequency of the surveys was determined by a combination of stream conditions from which new spawning entry might be anticipated, the need to survey the appropriate length of stream reach for the available time allotted, and the expected species to be found during a specified time period. Whenever possible surveys were timed to occur shortly after a peak flow event. During the typical fall/winter storm period of November through January this could result in peak flow events occurring and subsiding 2-3 times during a 10-day period. The 2014 storm events occurred in a way to provide difficult survey conditions for weeks at a time from January through March. Finney Creek is the largest of the creeks surveyed (average summer wetted width of 16 m at Quartz Creek entry at rkm 6.6 from Kiffney et al. 2006) and is particularly affected by lingering effects of heavy rainfall. Higher flow periods physically prevent the necessary wading to cover the survey reaches and turbidity is prolonged with inability to see redds. Thus considerable steelhead spawning is unavoidably missed in years of normal to greater winter precipitation. At the other end of the scale, Savage Creek has an extensive low gradient reach with wetlands and a series of ponds that it runs through resulting in moderation of its flows below those points with more gradual reactions to rainfall. It also has a significant upper fork that is particularly low gradient with wetlands and beaver ponds that it drains with related greater stability of flow characteristics. Dry, Mill, and O'Toole creeks all originate from steep mountain slopes which dominate their overall lengths with short 1 km sections or less of lower gradient where spawning occurs near their mouths. As a result their flows rise and fall quickly.

Because of the described differences in response to rainfall and drought, surveys had to be timed to these differences with variable frequency. At Finney Creek surveys were sometimes limited to zero per month or 1-2 per month in worst conditions. At smaller streams there could be as little as 1-3 days between surveys that occurred after a storm event in the hope of not missing any spawning activity prior to the next predicted storm. Any significant storm event could make some redds invisible thereafter. At the other extreme, during longer periods without significant rainfall the surveys could be delayed until a freshet occurred with a resulting wait of three weeks or more before anticipated new spawning. Some streams have particularly long survey reaches that may not fit the available time in a single day. In that case the survey lengths were broken up into shorter units that were done on multiple days within a short time of each other to capture the spawning for each stream reach between higher flow events. As a result of these considerations, surveys prior to March were often made at 3-4 day intervals if the sequence of rainfall and peak flow periods were frequent, after mid-March steelhead spawning survey intervals were often longer in more normal years (2014 being an exception) due to reduced high flow events, redd life being longer, and encountering hatchery steelhead and species other than steelhead less likely. As a result, active spawning sightings are less critical later in the survey season and the surveys were sometimes made further apart (10-14 days for instance).

Making wild and hatchery steelhead determinations was a primary survey objective of the spawner surveys. This meant maximizing the probability of finding active redds, or the presence of live steelhead during the surveys. However, finding active steelhead spawning in the Mid Skagit basin creeks has been a relatively uncommon occurrence. Live steelhead have also been noted as elusive sightings in other areas such as Oregon (Susac and Jacobs 1999). Active steelhead spawning was found in the Mid Skagit basin creeks to occur within 24-48 hours after a stream reaches a peak stream flow, which is typically considered to be the falling limb of the hydrograph. This rule of thumb largely concurs with the guidelines used in steelhead spawning surveys on the Oregon Coast (Susac and Jacobs 1999). In the case of Mid Skagit tributary steelhead, active spawning has most commonly been found during dimmer light conditions of cloudy days, and/or late afternoon and evening. At Prairie Creek in California steelhead spawning most commonly occurred at early morning and evening and steelhead vacated the redds at mid day to find cover for hiding (Briggs 1953). Needham and Taft (1934) found that the majority of steelhead redd construction at Waddell Creek occurred overnight under the confined

conditions of their observation method. The Waddell Creek example is an important consideration but doing the Mid Skagit surveys under the conditions of nightfall with extensive stream walks was not a realistic consideration. Given both past experience and guidance from the literature, cloudy days and late afternoon or evening were targeted for surveys at the Mid Skagit basin tributaries whenever possible as the best compromise regarding the apparent preference of steelhead to actively spawn at night or in otherwise dim lighting.

Estimating redd construction date

Steelhead redds are often found days to weeks after they were constructed. This can be due to unfavorable survey conditions due to high flows and lack of visibility, due to limited time to survey all streams within optimal conditions, or due to having missed sighting a redd until a later suvey date. When an inactive redd (i.e. no fish near the redd identified) was found, its age was estimated based on distinctiveness of the redd pit depth and tailing mound, and by winter or spring dates when the amount of algal growth on surrounding substrate and redds differ.

A redd was classified as built within a few days to a week of being identified if it was prior to March and the redd pit deep and tailing mound were well defined even though there was a small difference in the surrounding substrate coloration due to common absence of algal growth. A redd's age from March onward was similarly classified if it was of similar characteristics but the tailing mound was vey light coloration and surrounding substrate was distinctly darker due to the common presence of algal growth.

A redd was classified as being built one to two weeks earlier if it was prior to March and the redd pit was partially filled or less distinct and the tailing mound was less prominent even though there was little difference in the surrounding substrate coloration due to common absence of algal growth. A redd's age from March onward was similarly classified if it had similar pit and mound characteristics but the surrounding substrate was darker and some algal growth had initiated on the tailing mound.

A redd was classified as being built two to three weeks earlier if it was prior to March and the redd pit was more obscured and the tailing mound more dispersed. From March onward a redd's age was similarly classified if it had similar characteristics but the tailing mound was somewhat paler than surrounding darker substrate.

Redds identified before March were classified as built three to four weeks earlier if the redd pit was difficult to discern and the tailing mound was well dispersed but remained as visibly different from surrounding substrate despite lack of algal growth. From March onward a redd's age was similarly classified if it had similar characteristics but with algal growth on the tailing mound approaching that of the surrounding substrate.

These initial estimates of redd ages were noted in the field book. Subsequently, these redd age estimations were compared to streamflow and weather conditions that would have most likely stimulated spawning entry during or proximate to the estimated redd age range, and/or if it coincided with known spawning observed on the other streams or stream sections in that time frame. Thus final redd aging was based on a combination of these criteria.

Survey Procedure

Date and stream condition were recorded at the beginning of each survey. Flows were described as low, moderately low, normal for date, moderately high, high but surveyable, and high but unsurveyable. Water

visibility was described as clear (sufficient for survey), slightly discolored (sufficient for survey but impaired), and discolored (too diminished for a survey). Weather conditions such as amount of rainfall, snow, or freezing conditions in the days leading up to the survey were also noted. If ice conditions were present that was noted.

Along with a field notebook and a camera(s), surveys preferably began at the downstream end of the survey reach. The streambank was then walked upstream to the extent of the survey reach. However, in some instances of logistic necessity the survey was made by walking downstream. This occurred when access was limited to a bridge or culvert crossing upstream of the reach to be surveyed, or in the case of a larger stream (such as Finney Creek) when the only safe ford to cross the stream was upstream of the survey reach. In order to find passable terrain, the stream channel was crossed back and forth when possible. Care was taken to avoid live fish and redds. Each completed redd was recorded in the notebook by species and whether active or inactive. Sometimes older inactive redds could be difficult to determine, and/or by what species. These redds were typically counted based on probable species evidence, but the question was noted. Redds marked by previous surveyors were also counted (by WDFW in the case of Finney, O'Toole, and Mill creeks) if they similarly fit my redd identification criteria (generally so, but not always). If there was a ribbon associated with it, species and date was noted. If there was a flagged stone that was noted. Each carcass or live sighting was recorded by sex and hatchery or wild origin when possible. Unoccupied redds were considered completed if there remained evidence of a depression at the pit area and a gravel tailing behind. Active redds were counted as complete. A few active redds were difficult to otherwise determine in some habitat types where there are boulders that the spawning fish work around with several resulting scattered pits representing the egg laying by one female steelhead. This led to focused attention in these habitat types to determine if relatively small and scattered pits may be those of steelhead spawning. If several such small pits were found within a 15-30 meter reach of this type of stream habitat it was considered the egg laying of but one female steelhead. In other instances several fresh steelhead redds were found within a 50-100 meter stream reach but only one steelhead spawning pair was sighted. It is possible that just one female steelhead may have constructed all of the redds found (particularly in the smallest streams). However, without evidence to suggest otherwise, each redd found (unless within a few meters of each other) was counted as a separate redd representing that of one female steelhead. In the case of steelhead, coho, and cutthroat redds during overlapping spawning time periods, redd size was also recorded as a check on species use determinations.

I did not mark redds. One reason for this was so as not to confuse others who survey some of the same streams and do mark redds. Secondly, in the case of steelhead and cutthroat their redd infrequency did not require being marked and the number of streams surveyed was low enough so that memory did not tend to confuse newer redds from older ones if they remained visible between surveys at all. In the case of salmon, particularly coho and pink salmon, trying to flag all the redds would not have been particularly helpful due to frequent areas of superimposition or overlaps of redds. A combination of carcass, live fish, and redd counts was made each survey by species. The survey data from the field notebook were then analyzed and recorded at the end of each survey day so as to determine how well the carcass and live counts may or may not fit with the number of redds counted for salmon in particular. The primary purpose was to identify as well as possible steelhead spawning redds from the other species. This required careful examination of each redd by size, depth, and substrate used, and to further determine the most likely species use at that time interval which salmon live sightings, carcass presence, and live steelhead and/or cutthroat sightings helped to provide conclusions.

Determining Species Use by Redd Evidence

As noted in Oregon's steelhead spawning surveys (Susac and Jacobs 1999), because steelhead are so briefly in small streams for spawning, and due to their elusiveness and hiding compared to salmon, one is commonly left with only the remaining redds from which to make counts. Vacated redds pose the problem of determining the species that made them. Coho and sea-run cutthroat are the two species that more commonly spawn in the Mid Skagit basin tributaries during overlapping periods with steelhead. As the surveys have progressed the past five years some differences have been found to guide the methods for determining the species that have left vacated redds. Burner (1951) indicated that of the salmon redds assessed by species, only coho had as much as 10% mud in the substrate used and that they used slower flows than others. He also indicated that redd sizes generally reflect the size of fish (the larger the salmon the larger the redd, all else being equal) and that redd size is inverse to substrate size (the larger the gravel substrate the smaller the redd, all else being equal). These proved to be good guidelines.

In the case of the Mid Skagit tributaries, based on active spawning observations by each species, the smallest redds found were considered those of resident cutthroat (redds less than 1.5 ft x 1.5 ft, 0.25 sq. yds. considered such) or sea-run cutthroat (from 1.5 ft x 1.5 ft to 2 ft x 2.5 ft, 0.25 sq. yds. to 0.56 sq. yds.). Redds considered to be coho were larger (2 ft x 2.5 ft to 4 ft x 6 ft, 0.25 sq. yds. to 2.67 sq. yds.), and those considered to be steelhead larger yet (2 ft x 2.5 ft to 6 ft x 10 ft, 0.25 sq. yds. to 6.7 sq. yds.). Active cutthroat and coho redds were commonly at current edges or in slower currents. Such placements further guided determinations of inactive redds for those species while active steelhead redds were more commonly at mid channel or at edges to stronger currents and in larger substrate which further guided inactive steelhead redd determinations. Active coho redds were particularly found in side channels, even those down to wetted widths a meter or less with substrates that included considerable fine sediment and/or mud rarely if ever used by steelhead which further guided inactive redd decisions per species. Based on these criteria, inactive redd determinations made by species were made with relatively high confidence. Nevertheless, during a one to two week transitional period between coho and steelhead spawning in the Mid Skagit tributaries (latter January to mid February, depending on year and by tributary) a few vacated redds remained of some question regarding species origin. If active spawning was found by one or the other (coho or steelhead) during this period in one of the other four streams, it was considered likely that the questionable inactive redd found in the stream of question was likely made by the same species unless other criteria (such as redd size, location, or substrate size) indicated otherwise.

Determining Hatchery from Wild

Determining hatchery fish from wild was done by observing the presence (wild) or absence (hatchery) of the adipose fin by focused observation of individual fish during live sightings. Steelhead carcasses have yet to be found and can't be anticipated as an aid for determining hatchery or wild origin. Adipose fin presence or absence on live fish sighted has provided the only means to determine spawning time differences between wild and hatchery fish. Concentrated observation is required to determine steelhead adipose presence or absence, yet great care must be taken not to approach so closely as to cause flight and difficulty in finding the steelhead again. This can entail up to 1.5 hours of observation, but 20 to 40 minutes is often enough. It is particularly difficult in larger streams such as Finney Creek, but in the smaller streams the steelhead often spawn in shallow depths of 0.2-0.3 meters and eventually may lift the caudal fin out of the water providing clear momentary view of the adipose fin area. Determination of adipose presence or absence can be greatly facilitated by use of two digital cameras (Canon Power Shot SX50 HS digital camera and Go Pro, Hero 3 digital camera with underwater housing, the latter requiring a four foot long rod of to mount it on to more closely approach the fish beneath the water). The first camera was used for taking photographs of the spawning steelhead from above the surface and the second one for doing so beneath the surface and which was also the sequence used. The potential for

sending an adult steelhead into flight is greater with the underwater camera use, and therefore the choice to use it last. The latter camera was not used until the latter part of the spawning season but was found to be an important tool for both species determinations and whether of wild or hatchery origin.

Findings

Redd Counts

From October 3, 2013 through June 16, 2014, a total of 125 spawning surveys were made at five Mid Skagit basin tributary streams on a regular basis and at four other tributaries on an intermittent basis (Table 1 of Appendix C). The steelhead redds were enumerated by both the 7-8 day period found and adjusted to the estimated spawning date period during 2014 (Table 3).

Table 3. 2014 Mid Skagit Basin Steelhead Redd Counts by 7-8 Day Period

Steelhead redd counts by period found
Steelhead redd counts adjusted to estimated spawning period

Period	Savage		Mill		O'Toole		Finney		Dry		Total	
Dec 24-31												
Jan 1-7												
Jan 8-15		1										**1**
Jan 16-23	1								1	1	**2**	**1**
Jan 24-31								1		2		**3**
Feb 1-7							1		2		**3**	
Feb 8-15												
Feb 16-23	2	2							1	1	**3**	**3**
Feb 24-29												
Mar 1-7												
Mar 8-15	2	2						1	2	2	**4**	**5**
Mar 16-23								2				**2**
Mar 24-31						2	1	4			**1**	**6**
Apr 1-7					2			1			**2**	**1**
Apr 8-15				1			8	1			**8**	**2**
Apr 16-23												
Apr 24-30			2	1						1	**2**	**2**
May 1-7					1	1		3	1	1	**2**	**5**
May 8-15							7	6	5	4	**12**	**10**
May 16-23					1	1	3	1			**4**	**2**
May 24-31												
Jun 1-7												
Jun 8-15						1						**1**
Jun 16-23					1						**1**	
Jun 24-30												
Jul 1-7												
Total	**5**	**5**	**2**	**2**	**5**	**5**	**20**	**20**	**12**	**12**	**44**	**44**

Figure 1.

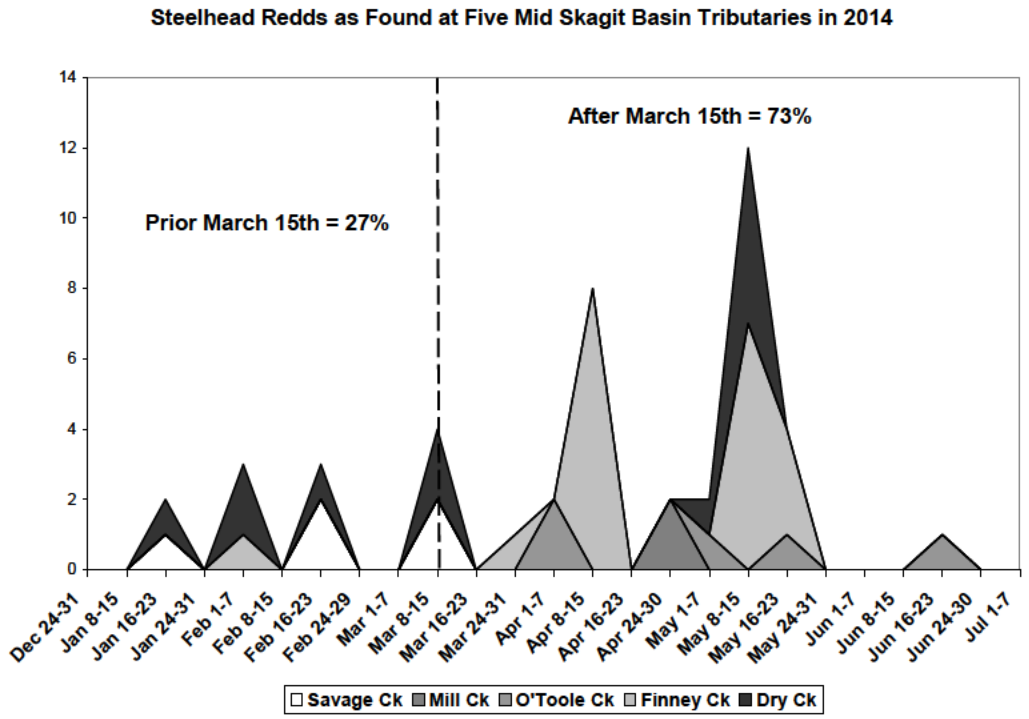


Figure 2.

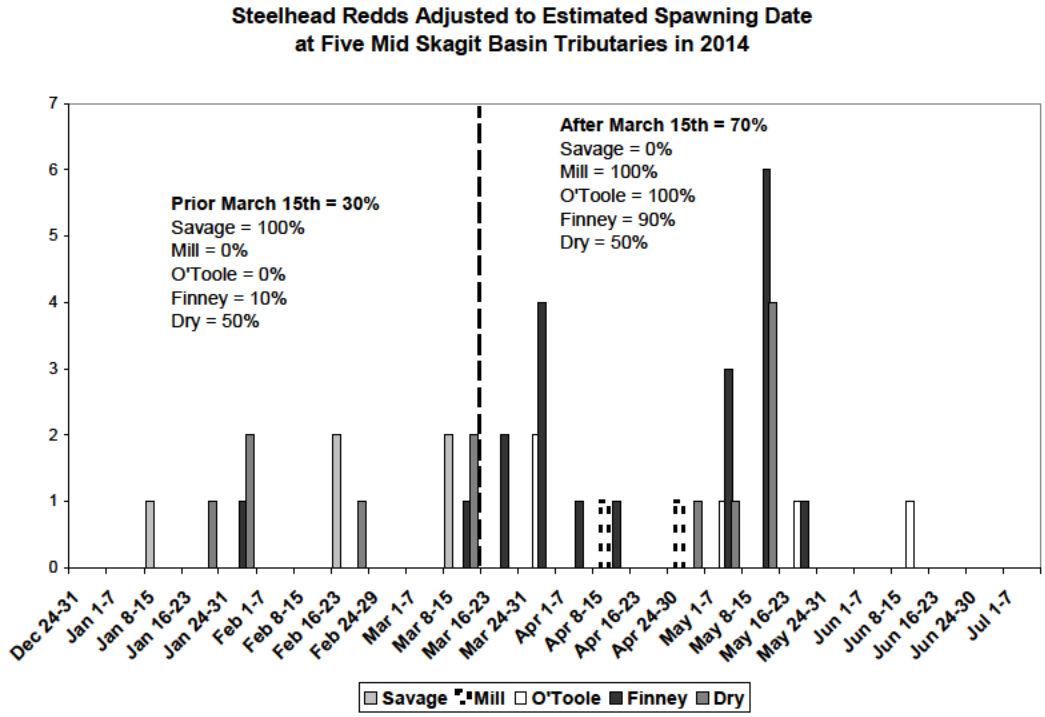


Table 4. Mid Skagit tributary steelhead spawning at streams regularly surveyed in 2014

Mid Skagit tributary	Earliest redd	Latest redd	Total redds	Redd upstream extent	Redds/km
Savage Ck	Jan 23, 2014	Mar 15, 2014	5	Mainstem = 1,997 yds; 1.826 km West Fork = 420 yds; 0 384 km	1.4/km
Mill Ck	Apr 30, 2014	Apr 30, 2014	2	578 yds; 0.529 km	2.4/km
O'Toole Ck	Apr 7, 2014	Jun 16, 2014	5	680 yds; 0.622 km	8.0/km
Finney Ck	Feb 1, 2014	May 22, 2014	20	3,825 yds; 3.498 km	5.7/km
Dry Ck	Jan 16, 2014	May 14, 2014	12	950 yds; 0.869 km	13.8/km

Table 5. Mid Skagit tributary steelhead spawning at streams intermittently surveyed in 2014

Mid Skagit tributary	Survey date(s)	Total redds	Redd upstream extent	Redds/km
Quartz Ck of Finney	May 16, 2014	0	none found	0
Hatchery Ck of Finney	Mar 23, 2014 & May 16, 2014	2	185 yds; 0.169 km	5.5/km
Grandy Ck	Feb 20, 2014	1	1,136 yds; 1.039 km	0.6/km
Cumberland Ck	May 2, 2014	2	852 yds; 0.779 km	3.8/km

Table 6. 2010-2014 Cumulative Mid Skagit Basin Tributary Steelhead Redd Counts by 7-8 Day Periods

Steelhead redd counts by period found

Steelhead redd counts adjusted to estimated spawning period

Date	Savage		Mill		O'Toole		Finney		Dry		Total	
Dec 24-31												
Jan 1-7												
Jan 8-15		1						1				**2**
Jan 16-23	3	2		2					1	2	**4**	**6**
Jan 24-31	1	3	6	4		1		3		4	**7**	**15**
Feb 1-7	1	3			1		3	2	2	2	**7**	**7**
Feb 8-15	4	2		1		1	6	4	5		**15**	**8**
Feb 16-23	4	2	4	3	1				1	1	**10**	**6**
Feb 24-29								1				**1**
Mar 1-7							3	1			**3**	**1**
Mar 8-15	2	2		3			1	2	2	2	**5**	**9**
Mar 16-23								2				**2**
Mar 24-31			4	1		2	1	4			**5**	**7**
Apr 1-7				1	2			2			**2**	**3**
Apr 8-15	1	1	1	3			11	5			**13**	**9**
Apr 16-23						1	1	1			**1**	**2**
Apr 24-30			3	3			2	1		1	**5**	**5**
May 1-7			1	1	1	2		4	1	1	**3**	**8**
May 8-15			3		2		7	6	5	4	**17**	**10**
May 16-23					1	1	5	1			**6**	**2**
May 24-31												
Jun 1-7												
Jun 8-15						1						**1**
Jun 16-23					1						**1**	
Jun 24-30												
Jul 1-7												
Total	**16**	**16**	**22**	**22**	**9**	**9**	**40**	**40**	**17**	**17**	**104**	**104**

The earliest and latest steelhead spawning redds, total steelhead redds, extent of steelhead spawning, and steelhead redds per kilometer by regularly surveyed tributary in 2014 are listed in Table 4 with a resulting six month breadth of steelhead spawning evidence found. The total length of the survey reaches is provided in Table 1 from which steelhead redds per kilometer were determined, except for Savage Creek where the steelhead survey length was 3,805 yds (3.479 km), or 604 yds (0.552 km) less than for total surveys included in Table 1 (Table 1 includes coho surveys further up the West Fork of Savage Creek). The steelhead spawning found at the Mid Skagit tributary streams intermittently surveyed are enumerated by date, total steelhead redds found, upstream extent, and steelhead redds per kilometer in Table 5. Although these surveys were too limited to be of comparative value to those streams regularly surveyed, in the cases of Cumberland and Hatchery Creek significant steelhead spawning per km was found. Grandy Creek was surveyed only once primarily to determine if early steelhead spawning had occurred. Only a little over 1 km of its lower section was surveyed of a total potential steelhead spawning length of at least 5.5 miles (8.85 km) to Grandy Lake. Although Quartz Creek was surveyed during a period when steelhead were spawning elsewhere in Finney Creek basin that it is tributary to, less than 0.20 km was surveyed of what is considered to be 0.80 km spawning habitat available to a cascade (Williams et al. 1975).

The cumulative steelhead redds at each of the five Mid Skagit tributaries regularly surveyed in the longer 2010 to 2014 period were enumerated by 7-8 day periods when they were found and also as adjusted to reflect their estimated spawning date in Table 6. The cumulative redds and live fish sightings for all species by tributary stream during this longer 5-year period along with notes about actual dates of redds and details related to live fish sightings are in Tables 1, 2, 3, 4, and 5 of Appendix C. At the five Mid Skagit basin tributaries regularly

Figure 3.

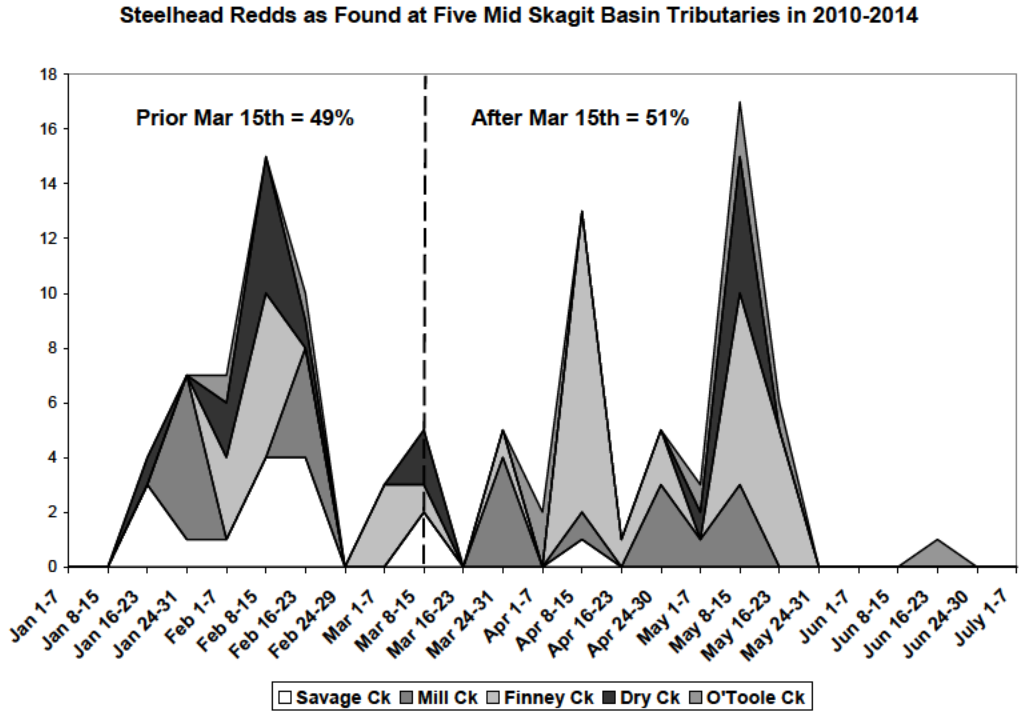


Figure 4.

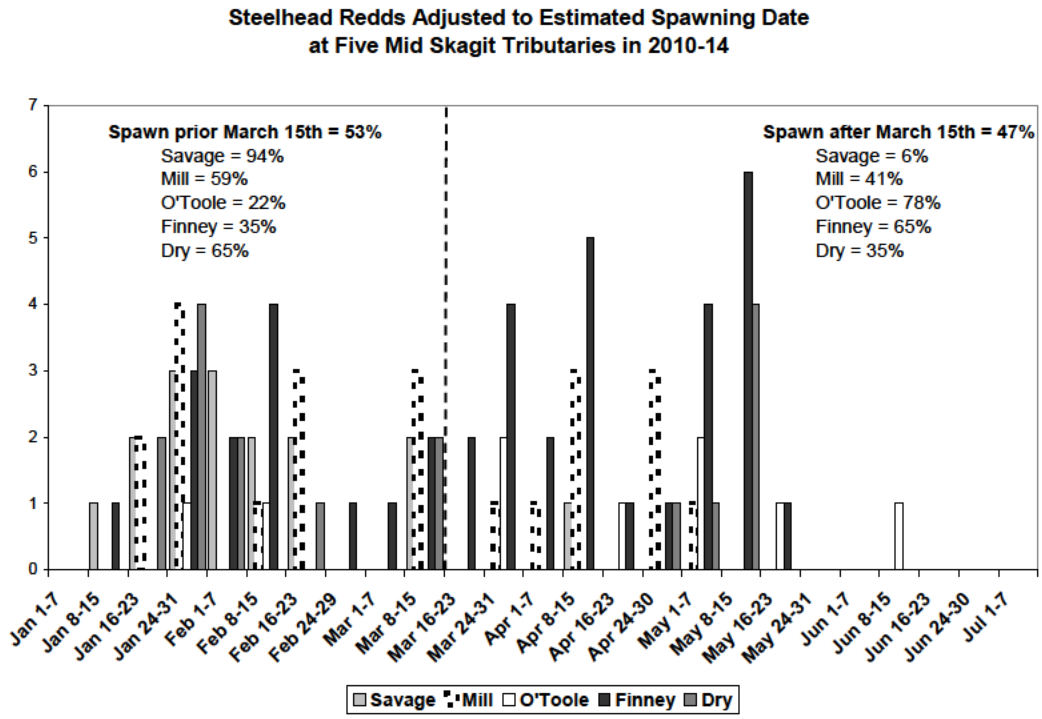


Table 7. Finney Creek Redd Counts by Time Period Found and as Adjusted to Reflect Estimated Spawning Period in 2010 and 2014

7-8 day period	2010 redds by period found	2010 redds by spawn period	2014 redds by period found	2014 redds by spawn period
Jan 16-23				
Jan 24-31		1		1
Feb 1-7	1		1	
Feb 8-15		1		
Feb 16-23				
Feb 24-29		1		
Mar 1-7	3	1		
Mar 8-15	1	1		1
Mar 16-23				2
Mar 24-31			1	4
Apr 1-7		1		1
Apr 8-15	3	4	8	1
Apr 16-23	1	1		
Apr 24-30	2	1		
May 1-7		1		3
May 8-15			7	6
May 16-23	2		3	1
May 24-31				
Totals	**13**	**13**	**20**	**20**

Figure 5.

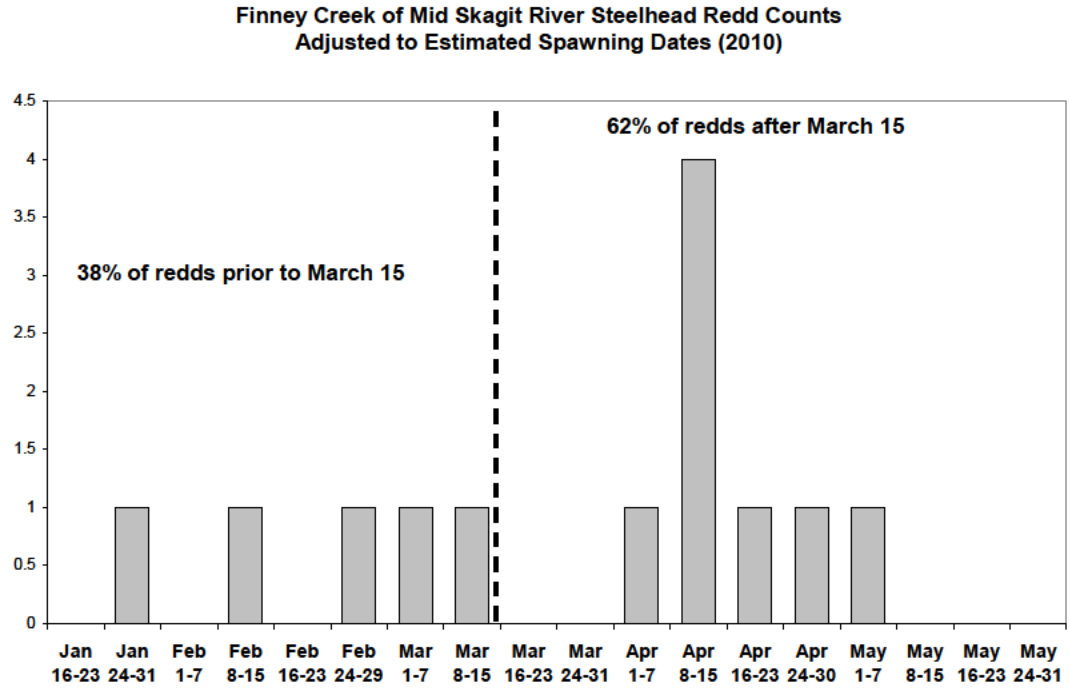
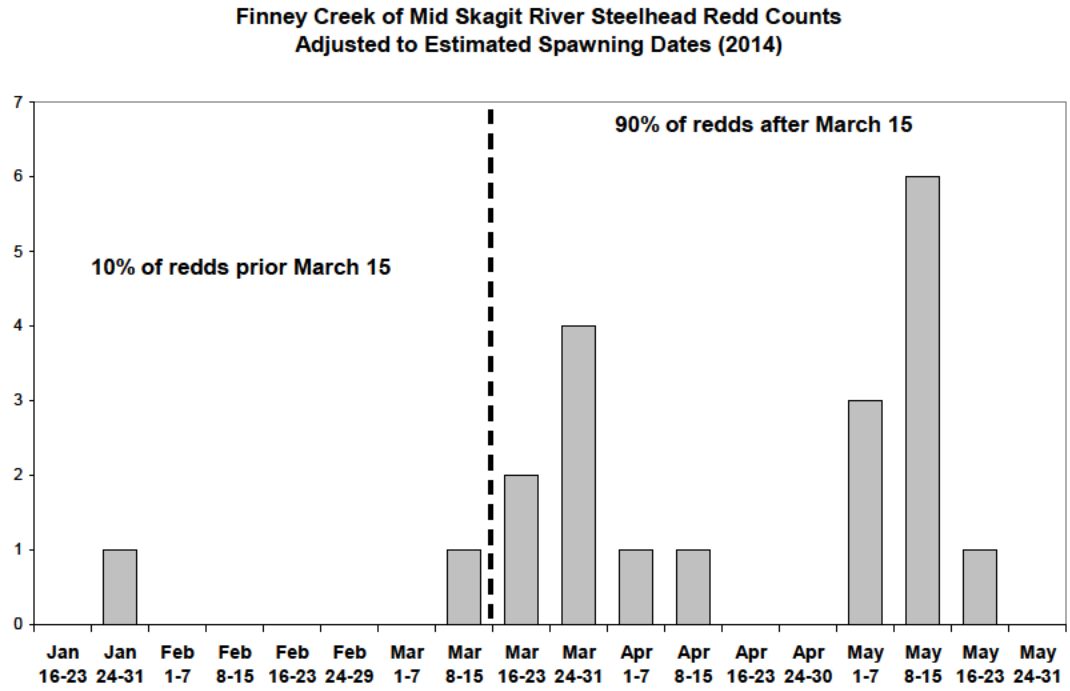


Figure 6.



surveyed from 2010 to 2014 the percentage of redds as found by 7-8 day intervals prior to and after March 15th are in Figure 3, and the percentages similarly found prior to and after March 15th in 2014 are in Figure 1. The

cumulative redds at each tributary from 2010 to 2014 as adjusted to reflect the estimated spawning date by 7-8 day intervals with percentages prior to and after March 15th are in Figure 4.

Finney Creek is the largest of the tributary streams regularly surveyed. Relatively similar intensity and duration of redd counts occurred at Finney Creek in 2010 and 2014 in which the age of each redd was also evaluated for its actual spawning date (Table 7). In 2010, 28% more spawning occurred prior to March 15th than in 2014 (Figures 5 and 6). Peak spawning in 2010 (early to mid April) was a month earlier than in 2014 (early to mid May), but the initiation of spawning was the same both years (late January).

Spawning Times Found for Wild and Hatchery Steelhead, Resident *O. mykiss*, and Other Salmonid Species

A primary purpose of the Mid Skagit basin tributary spawning surveys was to document whether hatchery steelhead spawning occurs, and if it overlaps with wild spawning. This could only be determined through visual observations of active spawning. A particular emphasis was placed on making active steelhead spawning observations during the 2014 steelhead spawning period of January through March when wild and hatchery overlaps in spawning time were thought to most probably occur. This entailed spending 0.5-1.5 hours of observation time when active spawning was found to make wild from hatchery determinations.

Sighting steelhead on spawning streams has been reported as relatively uncommon on the Oregon Coast, not only due to relatively small numbers compared to salmon but due to their nature to flee and hide (Susac and Jacobs 1999). This was similarly found in the Mid Skagit basin tributary surveys. During Mid Skagit tributary surveys active spawning was most commonly observed at late afternoon/evening and/or on cloudy days. It was also found that active spawning was most likely to occur within a 24-36 hour period after significant rainfall with streamflows dropping after their peak. The timing of the 2014 surveys was particularly adjusted to reflect this whenever possible. However, diminished lighting that steelhead apparently prefer for spawning has inherent limitations in visually determining the presence or absence of the adipose fin necessary for wild or hatchery identifications. Photographs were taken when active spawning was found as an aid to determine adipose presence or not, but absence of light also results in photographs with less definition than in brighter light. Nevertheless, photographs proved of great value. The active steelhead spawning found in Mid Skagit tributaries from 2010 to 2014 by sex and whether of wild, hatchery, or unknown origin is provided in Table 8. The resident *O. mykiss* life history is identified and listed if found as part of the active spawning mix. Also, the active spawning of *O.clarki* that is known to hybridize with *O. mykiss* is listed as observed.

The increased frequency of spawning surveys in 2014 resulted in the sighting of five incidences of female steelhead actively digging redds, or in the vicinity of where recent redd activity occurred. Four of these sightings occurred at Dry Creek, the smallest of the streams surveyed and the one where the greatest percentage of survey time occurred in ideal survey conditions of relatively low and clear flows very shortly after storm events. Spawning surveys at Dry Creek were not initiated until mid February of 2013 in the prior assumption that it was not a steelhead spawning stream based on earlier indications by other Skagit basin surveyors and due to my own brief observations contained to a bridge crossing near its mouth. Therefore the Dry Creek data is limited to two years, but it is now apparent that it is not only an important steelhead spawning stream but one which may provide a particularly reliable stream for effective monitoring of steelhead spawning at Mid Skagit tributaries. In the previous four years of surveys active steelhead spawning was only observed twice, once at Savage Creek and once at Finney Creek.

The resident form of *O. mykiss* was part of, or potentially a part of the spawning life history mix as determined at both Dry and Finney creeks. At upper Dry Creek, on January 16th of 2014 the only mate found with a hatchery female steelhead actively digging a redd was a wild male resident *O. mykiss*. However, the actual spawning act was not observed and could have potentially included a male steelhead thereafter. Another resident male *O. mykiss* was observed as part of the steelhead spawning mix at Dry Creek on March 12th of 2014. At Finney Creek on March 4th of 2010 and March 28th of 2014 a potential resident *O. mykiss* may have been present as part of each spawning mix. Throughout the adult steelhead collection period on Finney Creek in 2010 (related to the Skagit River steelhead acoustic tracking and tissue sampling for genetic analysis) a

Table 8. Species, life history, sex, and origin of live fish observed on redds occupied by female steelhead by tributary in cumulative surveys of the Mid Skagit basin in 2010-2014

Tributary	Date	Wild sthd ♀	Wild sthd ♂	Hat sthd ♀	Hat sthd ♂	? sthd ♂	Wild res *O. mykiss* ♂	Wild *O.clarki* ♂
Finney Ck	3/4/2010	1*				1*		
Savage Ck	1/19/2011			1	1	2**		
Dry Ck	1/16/2014			1			1	
Dry Ck	2/19/2014	1				1		1*****
Dry Ck	3/12/2014			1		1	1	
Finney Ck	3/28/2014	1***	1***			1****		
Dry Ck	5/12/2014	1	1					
Total		4 (21%)	2 (10.5%)	3 (15.8%)	1 (5.3%)	6 (31.6%)	2 (10.5%)	1 (5.3%)

* A large wild female darted off a redd along with the wake of at least one other fish as the mate; whether a male steelhead or larger resident *O. mykiss* was unknown; it was counted as a male steelhead of unknown origin

** These 2 male steelhead were vividly red-striped and fled on being sighted; the 2 hatchery steelhead did not flee; behavior suggested that the 2 fleeing fish were wild males but no sure visible evidence of adipose fin presence was made

*** This female and male steelhead were in slightly turbid water conditions that prevented seeing adipose fin presence or absence; due to their large size of an estimated 81-86 cm or more they were considered probable wild steelhead

**** It was not possible to determine if this was a smaller male steelhead or large resident male *O. mykiss* of an estimated 46-51 cm or if of wild or hatchery origin; a significant number of resident *O. mykiss* were sampled in Finney Creek in the winter and spring of 2009 for DNA analysis of similar size as were a few steelhead in the mainstem Skagit from 2008 through 2011

***** Probable male sea-run cutthroat based on finding a male *O.clarki* of similar size in the same place the next day spawning with a female *O.clarki*

significant number of resident *O. mykiss* of 15-20 inches (38.1-50.8 cm) was sampled (Pflug et al. 2013). Nearly all were males and most were in mature spawning maturation in the same time period as when the steelhead sampling occurred from early March to early May. As found on the Washington Olympic Peninsula Coast, the resident life history of *O. mykiss* found spawning was gender specific, males apparently mating with female steelhead (McMillan et al. 2007). This also concurs with observations at Waddell Creek in California in one of the earliest studies of steelhead spawning that included presence of male resident *O. mykiss* as part of the presumed spawning mix (Needham and Taft 1934).

The period of overlap for hatchery and wild *O. mykiss* spawning was January 16th through March 12th as found in the Mid Skagit tributaries, a total of 56 days (about two months). If the male *O. mykiss* of unknown origin

and life history that was part of the spawning mix at Finney Creek on March 28, 2014 was a hatchery origin steelhead it would lengthen the time period another 16 days (2.5 months total).

Figure 7.

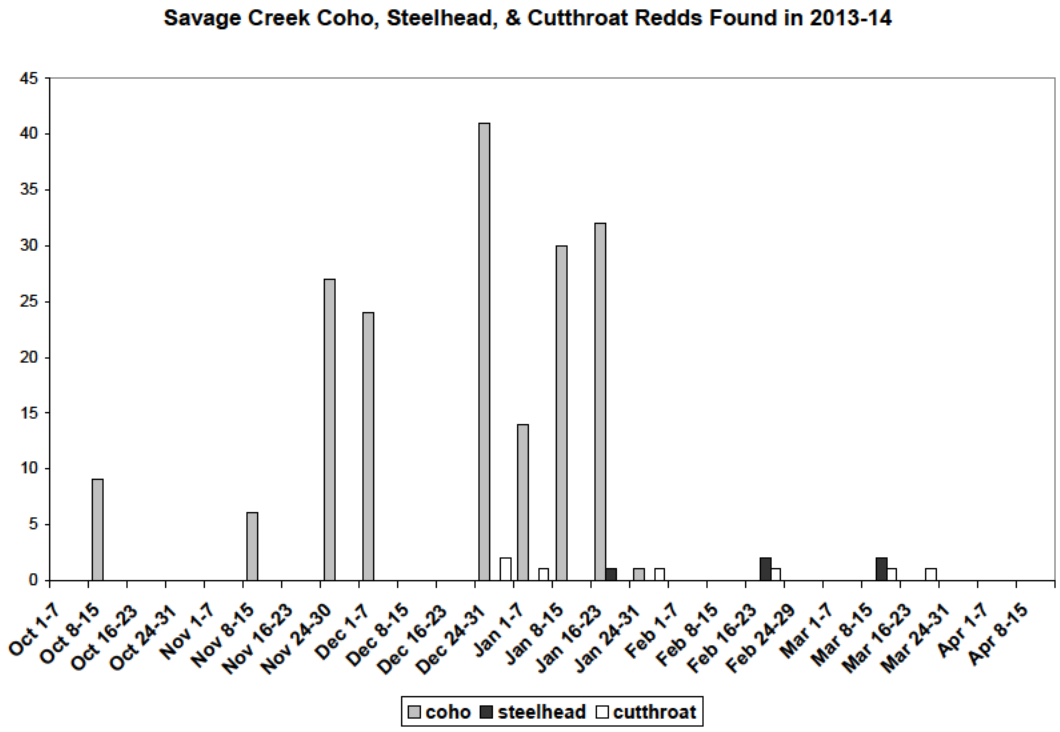


Figure 8.

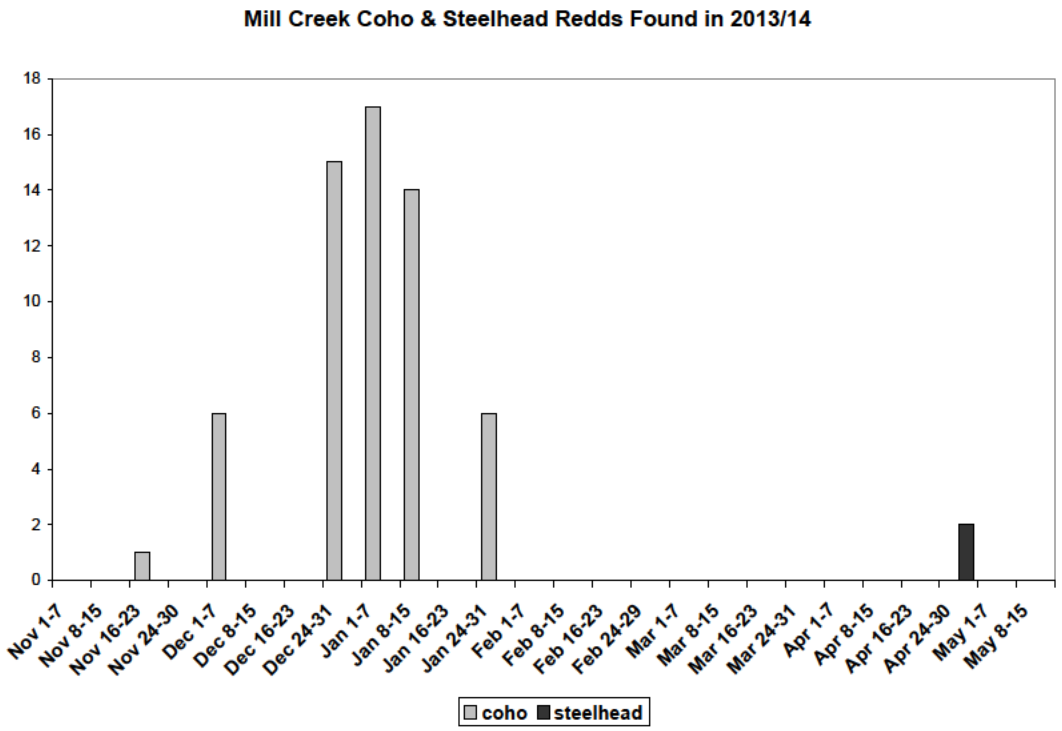


Figure 9.

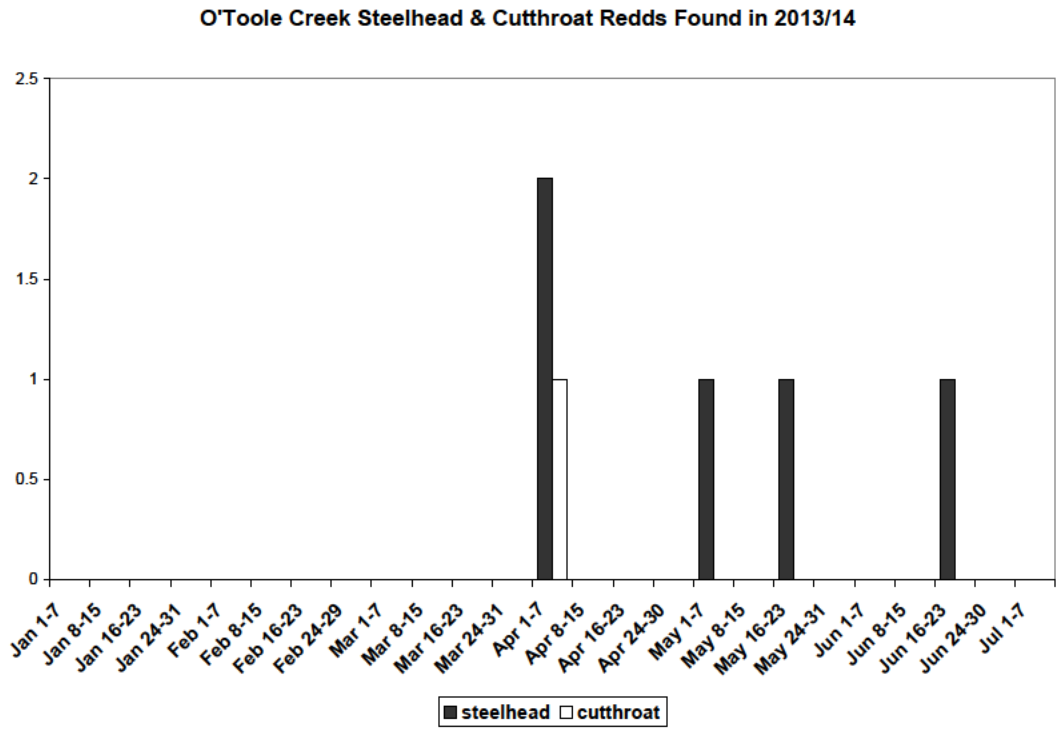


Figure 10.

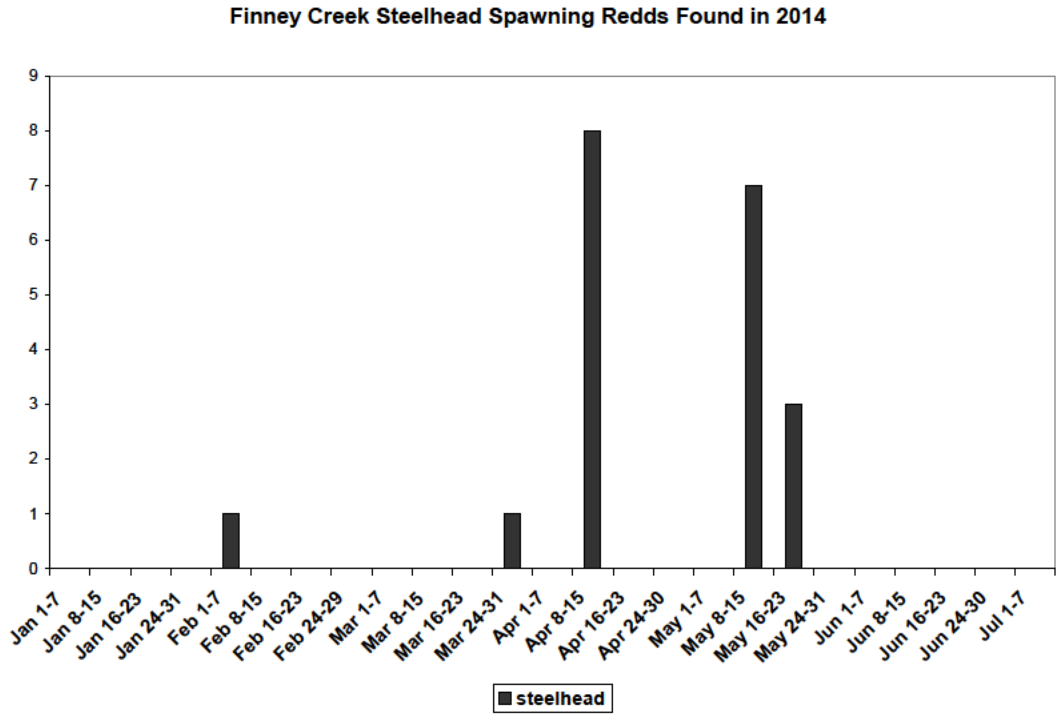
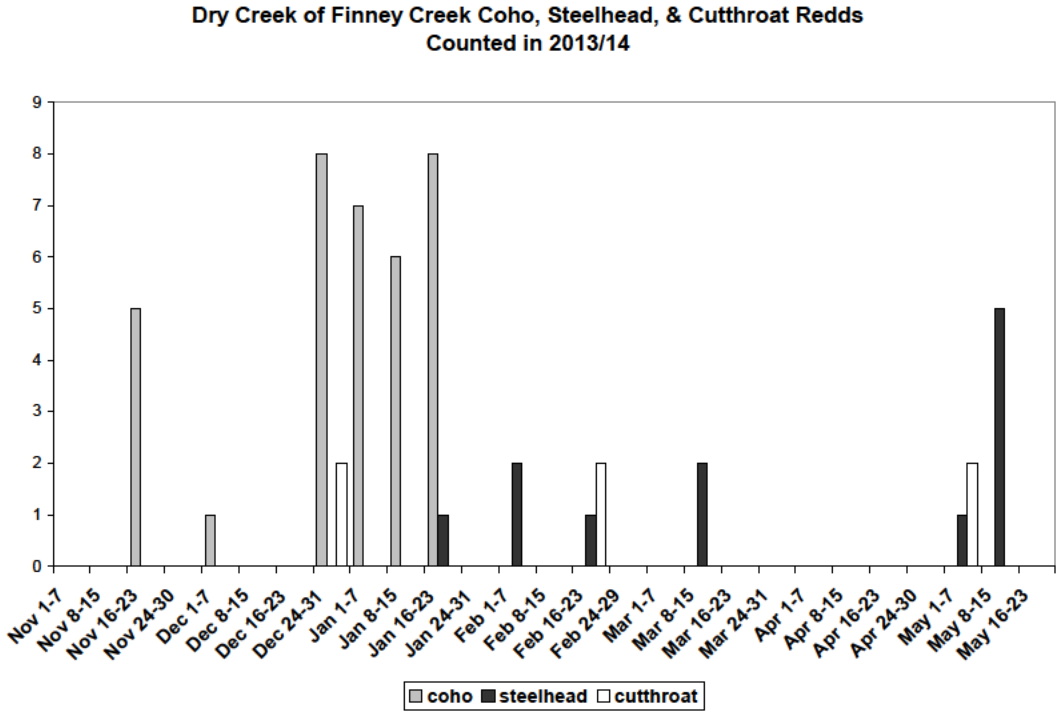


Figure 11.



In 2013-14 particular emphasis was also placed on determining what spawning overlaps may occur between steelhead and other species. Two other species of salmonids were found to have overlapping spawning periods

with steelhead (and resident *O. mykiss*), coho salmon (*Oncorhynchus kisutch*) and sea-run cutthroat (*Oncorhynchus clarki clarki*). This temporal overlap was more so for cutthroat than for coho. The first redd thought to be that of a sea-run cutthroat was latter December at both Dry and Savage creeks. The first and only active sea-run cutthroat spawning was found at Dry Creek on February 20th. The final redd thought to be that of a sea-run cutthroat was at Savage Creek in latter March, and a probable sea-run or resident cutthroat, or *O. mykiss* redd was found at Dry Creek in early May. The last live sea-run cutthroat was a male photographed at O'Toole Creek on May 15th. Figures 7-11 portray the overlaps with the other species as found at Dry, Mill, Savage, and O'Toole creeks during the 2013-14 October through early June survey period. In the case of O'Toole Creek, coho spawning has not been found to be very prevalent in previous years of surveys and in the 2013-14 surveys the temporal window of their potential overlap may have been missed due to a survey gap there from November 12, 2013 to March 12, 2014. At Finney Creek no surveys were made from October through January, primarily due to the difficulty of finding temporal survey windows that provided sufficient clarity to see redds or fish. In all instances in 2014, the transition from coho spawning to steelhead spawning was abrupt and well defined with but a minimal overlap over a one to two week period in mid to latter January.

Differences in Steelhead Spawning Time Found by Tributary

The differences in steelhead spawning times by tributary found in 2014 can be determined from the list of redd counts that have also been adjusted to estimated spawning dates in 7-8 day intervals in Table 3, and the differences by tributary over the five year period of 2010-14 are in Table 6. Steelhead redds as found by specific day for all years are listed in Appendix C, and in 2010 and 2014 in Appendix F (Tables 1 and 2). In 2014, the percentages of steelhead spawning prior to March 15th by tributary were: Savage Creek, 100%; Mill Creek, 0%, O'Toole Creek, 0%, Finney Creek, 10%, and Dry Creek 50% (Figure 2). Over the five year period of 2010-14, the percentages of steelhead spawning prior to March 15th by tributary were: Savage Creek, 94%; Mill Creek, 59%; O'Toole Creek, 22%; Finney Creek, 35%; and Dry Creek, 65% (Figure 4).

Determining Why There Were Steelhead Spawn Time Differences and Why It May Differ by Tributary

It was hypothesized that steelhead spawning time is determined by adaptations to environmental characteristics of spawning location among which are: temperature and streamflow/precipitiation during the spawning period, and perennial/intermittent flows that may determine egg-to-fry survival success. Each of these three factors was separately considered and evaluated from the data that were available, although in the cases of temperature and precipitation/streamflow the data available were not site-specific (Appendix G, Tables 1, 2, and 3 provide air temperature, precipitiation, and streamflow data primarily used from 2010 to 2014). However, even if more precise measures had been available by day and by hour it remained that the great majority of redds found were inactive and not in active spawning use. In some cases redds were estimated to not only be several days old, but weeks old. Without doing daily spawning surveys (commonly impossible due to adverse stream conditions) it may be impossible to develop a precise enough measure of when steelhead spawning actually occurs to be statistically informative enough to determine if correlations to environmental factors such as water temperature, air temperature, precipitation, or streamflow are significant or not. Nevertheless, each of these factors was considered and evaluated from what was available.

a) Temperature: stream temperatures were not measured during each spawning survey due to occurring at varied times of day, and differing days, at each tributary and would not necessarily provide equal comparative factors. There was no access to temperature loggers that could have been placed in each of the five primary tributary streams surveyed that would have been useful for recording water temperatures over the entire

spawning season of surveys. However, as previously indicated, even given a good measure of stream temperature per day and by hour, it remained that the great majority of redds found were inactive and not in active spawning use and a more precise measure of daily and hourly stream temperatures may not have resulted in any more informative comparison of water temperature to spawning time than the less direct methods used.

What was available was a former baseline of stream temperatures that I took in a number of Mid Skagit basin tributary streams in 2002 in preparation for spawning surveys that were then first planned. They were taken at 10-12 day intervals during a significant portion of the steelhead spawning season at near expected daily temperature peaks in latter afternoon (Table 9). While no record was found of stream temperatures for any of the tributary streams surveyed for 2010-2014, there is a long-term daily record of high, low, and mean air temperatures taken at the lower Baker River in Concrete, WA of the Mid Skagit basin that dates back to 1905 and with an interval of complete data from 1909 to 1915 and continuous information from 1931 to the present (WRCC). This historic baseline of air temperature information was used as a potential proxy for water temperature patterns that would have occurred, if not specifically the temperature of each stream. Monthly mean air temperatures were compared to the monthly steelhead redd counts and evaluated with Pearson's correlation coefficient to determine if there was a significant relationship or not.

b) Streamflow/Precipitation: there is presently no streamflow gaging station on any of the Mid Skagit tributaries that were surveyed. However, there was such a station at Finney Creek with streamflow recorded in cubic feet per second (cfs) in the period of 1943-48 (USGS 1943-1948). The North Fork Stillaguamish River has a streamflow gage between Arlington and Oso with streamflow data in cfs that is continuous dating from 1928 to the present. North Fork Stillaguamish streamflows have been considered to provide a surrogate for Finney Creek streamflows (USGS 1928-2014), and from which streamflow patterns during the steelhead spawning period at Finney Creek can be considered relatively equal (and potentially other Mid Skagit basin tributary streams). Alternatively, at the lower Baker River in Concrete, WA there is a long-term mean precipitation record kept that is of the same duration as previously described for air temperatures. It was hypothesized that precipitation pattern may provide a proxy for streamflow patterns at some Mid Skagit basin tributaries where the North Fork Stillaguamish/Finney Creek streamflow relationship may not as well fit. As with air temperatures, both monthly mean streamflow and precipitation were compared to the monthly steelhead redd counts and evaluated with Pearson's correlation coefficient to determine if there were significant relationships or not.

c) Perennial/Intermittent: it was hypothesized that steelhead spawning may be particularly limited in duration at those tributary streams that go intermittent by late June to early July due to the lack of subsequent egg-to-fry survival that may occur if spawning took place beyond a certain point in time. To test this, each creek that was regularly surveyed was subsequently examined after the end of the 2014 steelhead spawning season at regular intervals through June, July, and August to determine if any part went intermittent, when, where, and how far the intermittency occurred both downstream and up. Perennial streams were also determined in this same period.

Stream Temperature Findings

Reasons for the differences in steelhead spawning time found among the Mid Skagit tributaries could be related to water temperature as one measurable environmental effect (Cederholm 1984). Among the considerations for temperature differences by tributary was the buffering effect on flows and temperature during the spawning period as a result of ponds, lakes, or wetlands that may affect spawning time, or the directional orientation of a

tributary watershed (facing north and away from winter sun, or facing south and into the winter sun, for instance) may result in warmer or lower average temperatures, or the proportional distribution of the watershed area between higher and lower elevations.

The Table 10 stream temperatures were recorded on a Fahrenheit (F) scale with added conversions to Centigrade (C). Bell (1973) indicates that steelhead spawning occurs at 3.9-9.4 C (39.0-48.9 F). Bovee (1978) indicates steelhead spawning occurs at 4-13 C (39.2-55.4 F). These sources likely capture the general range of steelhead spawning temperatures found in Washington. Temperatures greater than 4.0 C (39.2 F) were considered adequate to initiate steelhead spawning. Temperatures of 3.9 C (39.0 F) were considered marginal for initiation of steelhead spawning. Using these criteria, Grandy Creek in 2002 would have provided adequate peak spawning temperatures throughout the February 9 to April 15 period. If the marginal temperature peaks are included, both the mainstem Mid Skagit River and Finney Creek could have initiated steelhead spawning through most of that same period. Mill and Pressentin creeks had adequate to marginal temperature peaks to initiate steelhead spawning for three of the seven temperature points in that period. O'Toole Creek had only two of those seven temperature periods adequate for spawning. In all three of the latter creeks, these temperature periods were confined to latter March onward. In the case of Grandy Creek (only rarely surveyed), with warmer water temperatures within the range for steelhead spawning throughout the February to April period of 2009, important considerations are a lake in its headwaters and a south facing aspect of the drainage into the winter sun on the north side of the Skagit Valley. The combined lake and orientation to the sun is a likely combination from which to anticipate the warmer winter/spring stream water temperatures found and that steelhead spawning temperatures occur there at what may be a particularly early date. Although Grandy Creek was surveyed early in the spawning season (February) in 2010, 2011, 2013, and 2014 with steelhead redds found in the surveys three of those years (2010, 2013, and 2014) whose estimated spawning dates included January, no later surveys were done for comparison (Appendix C). Nevertheless, it is apparent that Grandy Creek is one of the Mid Skagit basin tributaries where steelhead spawning prior to March 15th is common.

While the Table 10 data is generally useful as a potential guide to determining what stream characteristics and subsequent peak spawning temperatures might temporally stimulate steelhead spawning to occur in the Mid Skagit area, it includes only three of the five creeks regularly surveyed in 2014 (Finney, Mill, and O'Toole creeks) and one creek rarely surveyed (Grandy Creek).

Table 9. Mid Skagit basin peak stream temperatures at 10-12 day intervals

Stream Orientation & etc.	**Temp F/C**	**Water temperature by 10 day intervals February 9 to April 15, 2002**							**Mean Temp**
		2/9	**2/19**	**3/2**	**3/12**	**3/24**	**4/3**	**4/15**	
Grandy Ck (faces south & lake & wetland headwaters)	F C	40.5 4.72	40.5 4.72	41.0 5.00	40.0 4.44	44.25 6.81	46.0 7.78	42.25 5.69	42.08 5.60
Skagit River (5 dams & reservoirs)	F C	39.0 3.89	39.5 4.17	39.5 4.17	38.5 3.61	43.75 6.53	44.0 6.67	40.5 4.72	40.68 4.82
Finney Ck (faces n.w. & long lower reach of low gradient)	F C	39.0 3.89	39.5 4.17	38.5 3.61	38.5 3.61	42.5 5.83	45.0 7.22	40.75 4.86	40.54 4.74
Mill Ck (faces north)	F C	38.5 3.61	38.5 3.61	37.5 3.06	38.0 3.33	40.0 4.44	40.0 4.44	39.5 4.17	38.86 3.81

Pressentin Ck	F	38.0	38.5	36.5	37.5	39.75	40.25	39.0	38.50
(faces north)	C	3.33	3.61	2.50	3.06	4.31	4.58	3.89	3.61
O'Toole Ck	F	38.0	38.0	36.0	37.0	39.5	39.75	38.75	38.14
(faces north)	C	3.33	3.33	2.22	2.78	4.17	4.31	3.75	3.41

Temperatures shaded in light gray are within the common range of steelhead spawning (Bell 1972, 3.9-9.4 C; Bovee 1978, 4-13 C) and dark gray marginally included. (Orcutt, 1968, indicated Idaho steelhead in the headwaters of the NF Clearwater River spawn at 2.2-8.3 C, but it is at a much higher elevation than Western Washington streams. Nevertheless, it suggests that steelhead can spawn at lower temperatures.)

From summer temperature data at the five Mid Skagit tributaries regularly surveyed in 2014 (Table 10), on June 16th of a cloudy, cool day Finney Creek was again the warmest temperature and O'Toole Creek the coldest with Mill Creek slightly warmer than O'Toole. However, the mainstem Mid Skagit River was nearly as cold as O'Toole Creek. This was to be expected in June due to peak snowmelt from the North Cascade Mountains then occurring with several headwater origins from glaciers. Savage Creek, which runs through a series of ponds and wetland areas from 0.5 to 1.0 kilometer (km) above entry to the Skagit River, was 4.4 C warmer 135 meters (m) below the largest main pond than 125 m above it. Dry Creek, an otherwise unnamed tributary of lower Finney Creek, was colder than Finney and lower Savage Creek, but warmer than Mill, O'Toole, and upper Savage Creek.

Flows rapidly diminished and heated from late June to mid July, except in the mainstem Mid Skagit River. The period from July 9 to July 14 of 2014 on the Mid Skagit Valley floor had afternoon peaks of 80-85 F (26.7-29.5 C) as taken near the mouth of Savage Creek. While the mid June temperatures were taken during a cooler and stable temperature day, as can be common in June in the Mid Skagit Valley, the mid July temperatures represent what is a common high temperature period during most summers in the Mid Skagit Valley. Morning temperature was taken at Mill Creek on July 13th as representative of cooler tributary streams during warmer

Table 10. Mid Skagit River and five tributary creek air and water temperatures in summer of 2014

warmest by date coolest by date

Creek	Section	Date	Time	Weather	Air Temp		Water Temp	
Finney Ck	3.5 km above mouth	6-16-2014	4:05 pm	cloudy cool	57.0 F	13.9 C	57.0 F	13.9 C
Dry Ck of Finney	250 m above mouth	6-16-2014	4:00 pm	cloudy cool	57.0 F	13.9 C	51.5 F	10.8 C
Mill Ck	90 m above S. Skagit Hwy	6-16-2014	4:20 pm	cloudy cool	57.0 F	13.9 C	49.5 F	9.7 C
Savage Ck	125 m above main pond	6-16-2014	5:15 pm	cloudy cool	57.0 F	13.9 C	51.0 F	10.6 C
Savage Ck	135 m below main pond	6-16-2014	5:10 pm	cloudy cool	57.0 F	13.9 C	59.0 F	15.0 C
O'Toole Ck	70 m above S. Skagit Hwy	6-16-2014	4:40 pm	cloudy cool	57.0 F	13.9 C	48.5 F	9.2 C
Mid Skagit Riv	Savage Bar	6-16-2014	6:15 pm	cloudy cool	58.0 F	14.4 C	49.0 F	9.4 C
Mill Ck	25 m below S. Skagit Hwy	7-13-2014	10:20 am	sunny warm	69.0 F	20.6 C	57.5 F	14.2 C
Savage Ck	250 m above main pond	7-13-2014	9:35 am	sunny warm	66.0 F	18.9 C	54.5 F	12.5 C
Savage Ck	135 m below main pond	7-13-2014	10:00 am	sunny warm	68.0 F	20.0 C	69.5 F	20.8 C
Finney Ck	4.0 km above mouth	7-13-2014	8:30 pm	sunny warm	70.0 F	21.1 C	70.5 F	21.4 C
Dry Ck of Finney	450 m above mouth	7-13-2014	8.15 pm	sunny warm	70.0 F	21.1 C	63.5 F	17.5 C
Savage Ck	135 m below main pond	7-13-2014	8:48 pm	sunny warm	69.0 F	20.6 C	75.0 F	23.9 C
Mill Ck	25 m below S. Skagit Hwy	7-13-2014	8:52 pm	sunny warm	68.0 F	20.6 C	59.5 F	15.3 C
O'Toole Ck	70 m above S. Skagit Hwy	7-13-2014	9:00 pm	sunny warm	68.0 F	20.0 C	59.5 F	15.3 C
Mid Skagit Riv	Savage Bar	7-13-2014	9:15 pm	sunny warm	68.0 F	20.0 C	55.0 F	12.8 C
Savage Ck	135 m below main pond	7-14-2014	8:13 pm	sunny warm	70.0 F	21.1 C	75.5 F	24.2 C

Savage Ck	450 m above main pond	7-14-2014	8:30 pm	sunny warm	68.0 F	20.0 C	58.0 F	14.4 C
Finney Ck	3.5 km above mouth	8-16-2014	4:45 pm	cloudy warm	69.5 F	20.8 C	68.0 F	20.0 C
Dry Ck of Finney	350 m above mouth	8-16-2014	4:30 pm	cloudy warm	69.5 F	20.8 C	62.0 F	16.7 C
Mill Ck	30 m above S. Skagit Hwy	8-16-2014	3:00 pm	cloudy warm	69.5 F	20.8 C	59.5 F	15.3 C
Savage Ck	450 m above main pond	8-16-2014	5:20 pm	cloudy warm	69.5 F	20.8 C	58.0 F	14.4 C
Savage Ck	below main pond dry	8-16-2014	5:05 pm	cloudy warm	69.5 F	20.8 C	dry	
O'Toole Ck	70 m above S. Skagit Hwy	8-16-2014	3:20 pm	cloudy warm	69.5 F	20.8 C	59.0 F	15.0 C
Mid Skagit Riv	Savage Bar	8-16-2014	5:45 pm	cloudy warm	69.5 F	20.8 C	59.5 F	15.3 C
Finney Ck	3.5 km above mouth	8-28-2014	8:00 pm	cloudy warm	65.0 F	18.3 C	70.0 F	21.1 C
Dry Ck of Finney	400 m above mouth	8-28-2014	7:50 pm	cloudy warm	65.0 F	18.3 C	62.0 F	16.7 C

summer weather periods, and at Savage Creek to measure both the inflow temperature to its pond/wetland reach as well as the outflow. Evening temperatures were taken on July 13-14 at all of the streams to represent water temperatures at near their peak during warmer summer periods (although evening may represent some slight cooling from what may be an actual peak a few hours earlier). The highest temperatures were at Finney Creek (70.5 F; 21.4 C) and Savage Creek below the uppermost pond (75.5 F; 24.2 C). At the latter juvenile coho and undetermined species fry were active and seemingly healthy. The coolest temperatures were at O'Toole Creek (59.5 F; 15.3 C) and the Mid Skagit River (55.0 F; 12.8 C). The summer peak air temperature occurred on August 11th at 93 F (33.9 C) near the mouth of Savage Creek (near Birdsview) and was preceded by several days in mid to high 80 F (26.7 C) range. Unfortunately, no time was available to take stream temperatures in that time period, but Finney Creek would have peaked considerably higher than on July 13th as the stream with the probable warmest summer peak temperature of those that remained wetted. Savage Creek below the ponds went dry by early August as the previous water temperature peak. On August 28, even at late evening after a mild late afternoon high of 70 F (21.1 C), Finney Creek was also 70 F, while Dry Creek was 62 F (16.7 C) just upstream of where it was dry.

The combined findings of water temperatures taken from early February to Mid April (Table 9) in the steelhead spawning period at Mid Skagit Basin tributaries and the shift to mid June and later (Table 10) indicate that the shift to maximum water temperatures beyond which steelhead spawning may cease at 9.4-13.0 C (48.9-54.5 F) as previously indicted by Bell (1973) and Bovee (1978) likely begins sometime between May and mid June at four tributaries (Savage, Mill, Finney, and Dry creeks), while continuing into June at O'Toole Creek. The actual steelhead spawning found in these same five tributaries further confirms this likelihood (Table 7).

Between 2000 and 2011 stream water temperatures were recorded at several Mid Skagit tributary streams at broadly spaced times while doing sampling or spawning surveys (Table 11). For the most part they merely confirm the previous temperature findings in Tables 10 and 11. However, it includes the active spawning period of January 19, 2011 at Savage Creek with the water temperature taken at the spawning location below

Table 11. Mid Skagit Basin Tributary Water Temperatures Taken at Varied Times Compared to Air Temperatures

Active steelhead spawning period

Tributary	Date	Time	Water temp (F)	Concrete air temp (F) low-high	Birdsview air temp (F)	Notes
Mill	7-21-2000	2:20pm 4:30pm	55 55	n/a	80 afternoon high	....

Mill	7-3-2007	3:45pm	54	52-78.1	....	....
O'Toole	2-3-2010	3:00pm	42	37-48	....	El Nino year
Mill	2-4-2010	2:30pm	42	37-44	....	El Nino year
Finney	2-6-2010	1:30pm	44	35-50	....	El Nino year
Pressentin	2-8-2010	1:30pm	41.5	41-48	....	El Nino year
Grandy	2-8-2010	2:15pm 3:30pm	44 44	41-48	....	El Nino year
Finney	4-13-2010	afternoon	44	39.9-60.1	....	El Nino year
Cumberland	6-25-2010	12:30pm	54	55-75.9	....	....
Mill	1-19-2011	4:50pm	39	36-39.9	....	....
Savage	1-19-2011	4:40pm	42	36-39.9	....	active spawning below pond outlet & where temperature taken
Mid Skagit	1-19-2011	5:00pm	40	36-39.9	....	....
Grandy	2-2-2011	2:00pm	40	27-39.9	21 morning low	very cold morning

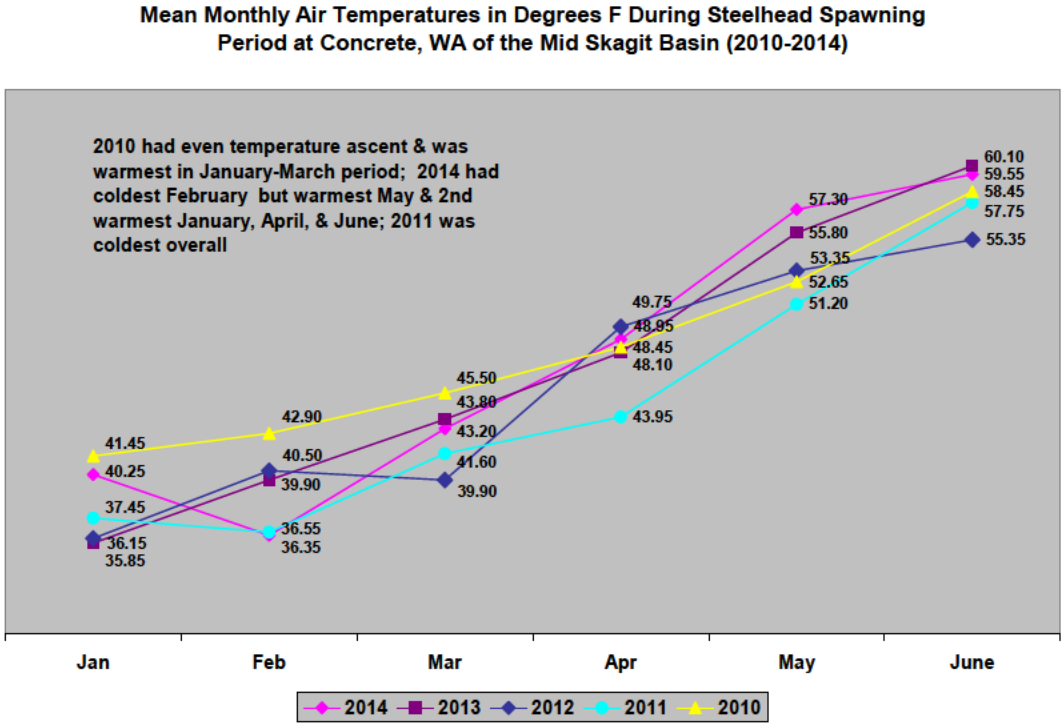
upper Savage pond. The water temperatures were similarly taken at the same day and time at nearby Mill Creek and the Mid Skagit River. The table also includes the Concrete, WA air temperature range (low and high) for each day (north side of the Mid Skagit River) and that at Birdsview, WA (south side of the Mid Skagit River) if available for the same days. The active spawning found at Savage Creek was on a relatively cool day (air temperature at Concrete being a low of 36 F and a high of 39.9 F) and at a water temperature of 42 F. At the same time, Mill Creek was 39 F and the Mid Skagit River 40 F, both cooler. Savage Creek was well within the temperature range indicated in the literature for steelhead spawning (depicted in Table 9) while that at Mill Creek and the Mid Skagit River were at the low to marginal end of the spawning temperature range. Between February 4 and 8 of 2011 there was a period of relatively stable air temperature and weather conditions during which afternoon water temperatures were taken at Mill (42 F), O'Toole (42 F), Finney (44 F), Grandy (44 F), and Pressentin (41.5 F) creeks of the Mid Skagit basin.

While the above stream temperature findings provide indicators of when typical steelhead spawning time windows can begin in Mid Skagit basin tributary creeks according to literature sources, and which of the streams tend to run cooler or warmer, there was only the one active spawning-to-temperature comparison made that also included temperatures taken at other nearby tributaries and the Skagit River during the 2010-14 cumulative spawning surveys made, that being Savage Creek on January 19, 2011 as compared to Mill Creek and Skagit River temperatures at the same time (Table 11).

Air Temperature Findings

Although average monthly water temperatures were not kept for any of the tributaries surveyed, and no similar data have been found available, monthly air temperature data is available for Concrete, Washington of the Mid

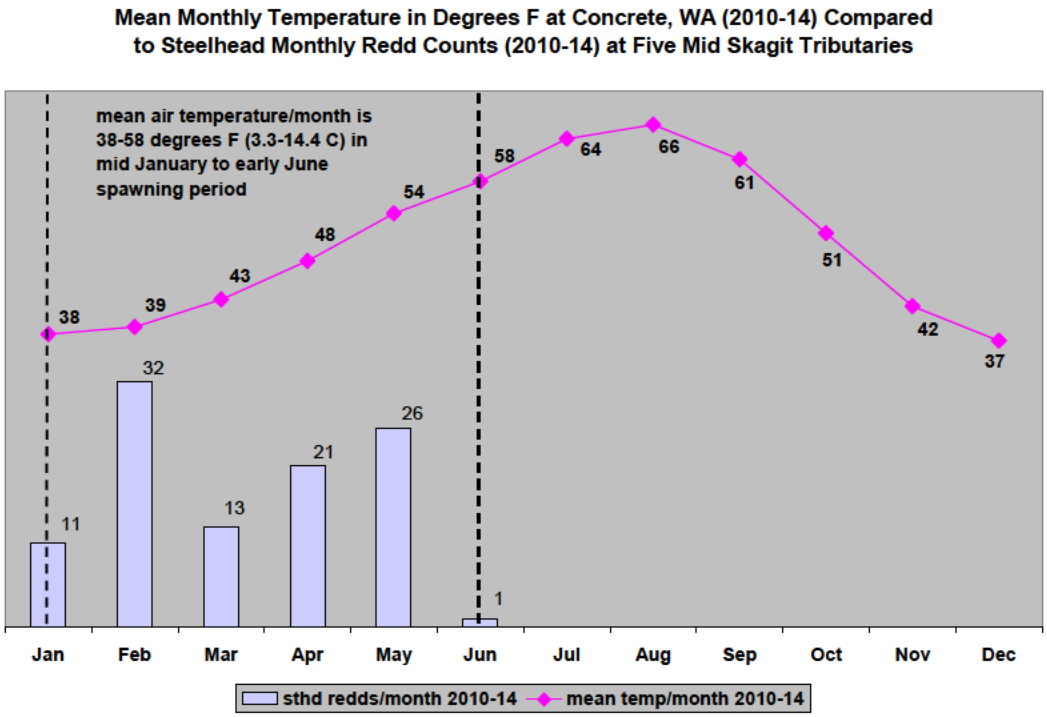
Figure 12.



Skagit basin (WRCC 2014) and may provide a proxy for water temperature trends if not water temperatures themselves. Figure 12 provides the mean monthly air temperature patterns for each year at Concrete during the steelhead spawning period from 2010 to 2014 (Appendix G, Table 1 provides the temperatures per month). The monthly air temperatures in 2010 were higher from January to March than the other years and progressed upward at a gradual and even rate that ended up cooler in May compared to other years. The February mean air temperature was colder in 2014 than the other years but warmest in May and second warmest in January, April, and June. On whole, 2011 was the coldest of the years during the steelhead spawning period.

Steelhead spawning redds per month by date found at the Mid Skagit basin tributaries as compared to monthly mean air temperatures during the steelhead spawning period of the 2010-2014 surveys (Figure 13) suggest that steelhead spawning generally increases as mean air temperatures do from January (38 F, or 3.3 C) through May

Figure 13.



(54 F, or 14.4 C). The exception to what is otherwise an even progression of steelhead redds to increasing mean monthly air temperature is February as the month found with the single greatest number of steelhead redds. However, when the 2010-2014 steelhead redds found were adjusted to estimated spawning date, presumably the more relevant comparison, it results in what appears to be a slight inverse relationship to mean temperature per month with spawning apparently diminishing as temperatures rise (Figure 14).

While it was obvious during the surveys that a number of redds found were several days to several weeks old, the actual spawning time could only be estimated by personal judgment based on amount of algae on the redd, how vague its pit or tailing had become, and/or the prior periods when there had been spawning in near-by tributaries or otherwise what had seemed the best stream conditions for steelhead entry into these streams. In a number of instances, the judgments made regarding spawning date could have been pushed forward into the next month or dropped back into the following month. In this regard, spawning survey methods as limited by weather/water conditions do not lend to precision of spawning date determination by month for all redds. For this reason, both the dates when the redds were found and the estimated spawning dates have been comparatively evaluated for temperature (as well as for precipitation and streamflow).

A further evaluation of the potential relationship of air temperatures to the steelhead redds by date found in the primary steelhead spawning period from January to June was made (Figure 15) with a resulting Pearson's correlation coefficient, or "r", of - 0.3501, which is not statistically significant using critical values from the

Figure 14.

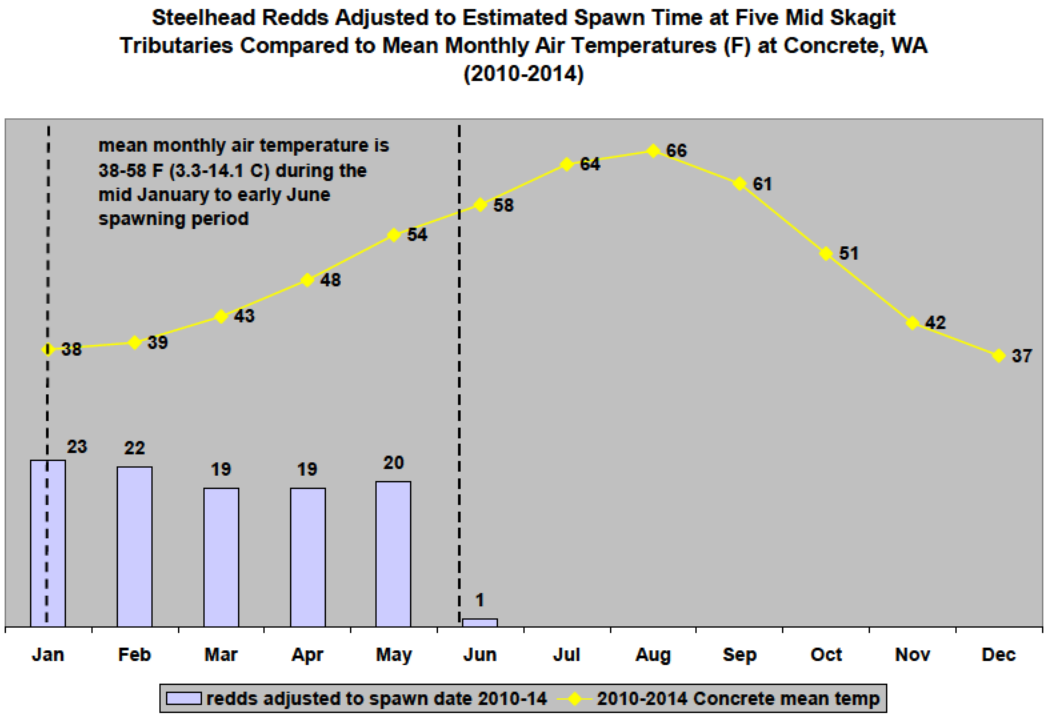


Figure 15.

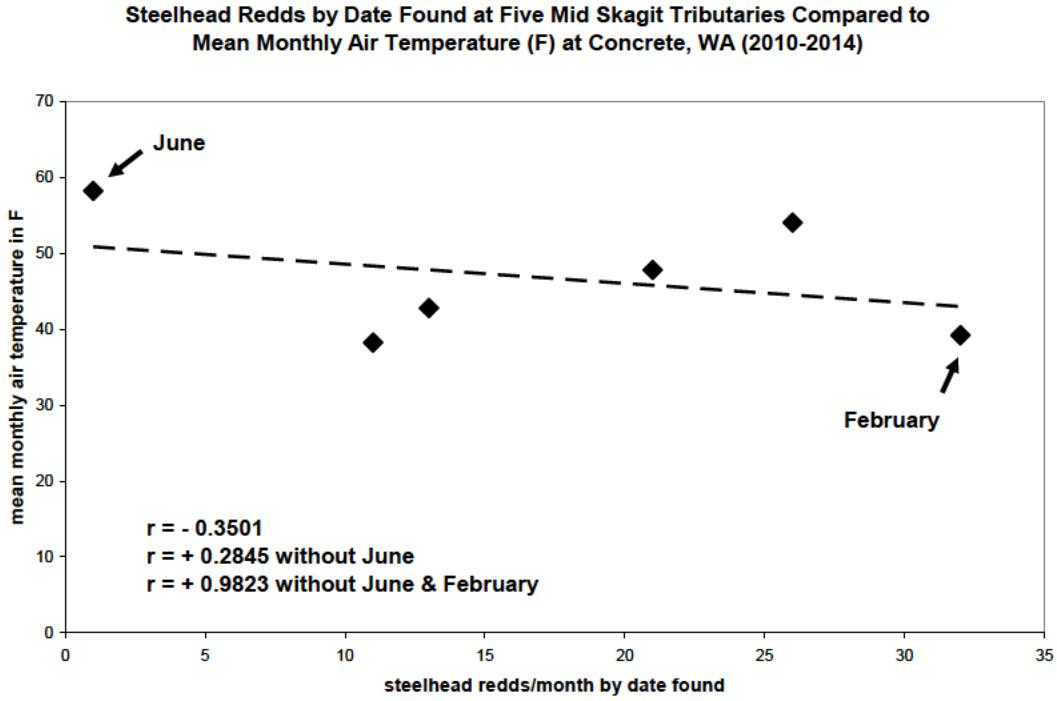
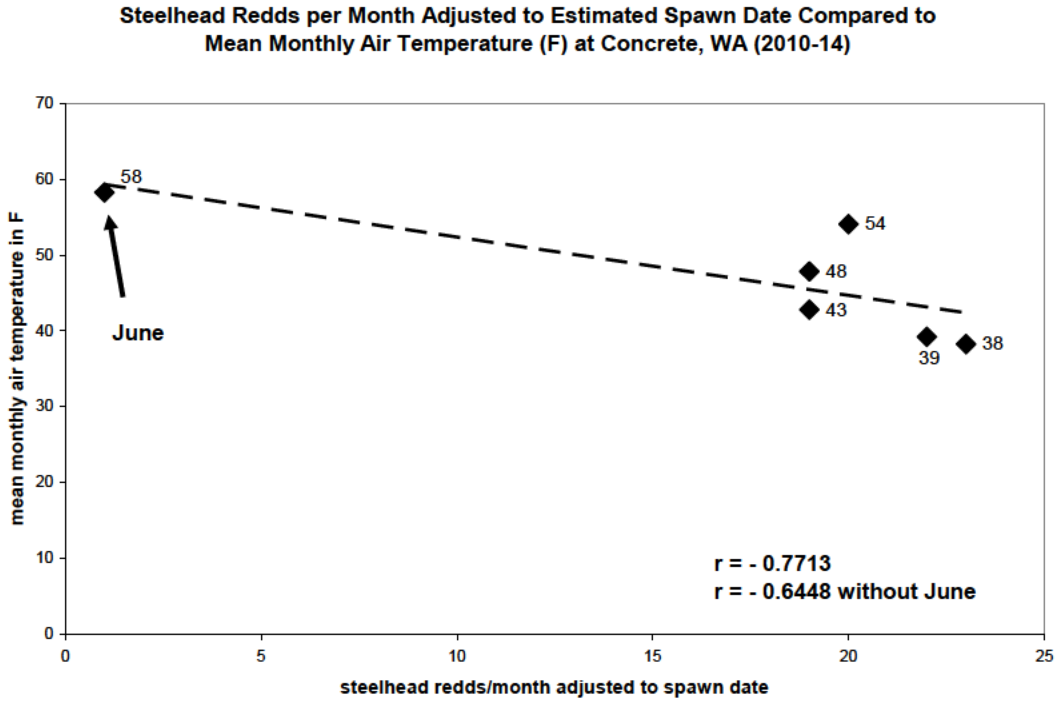


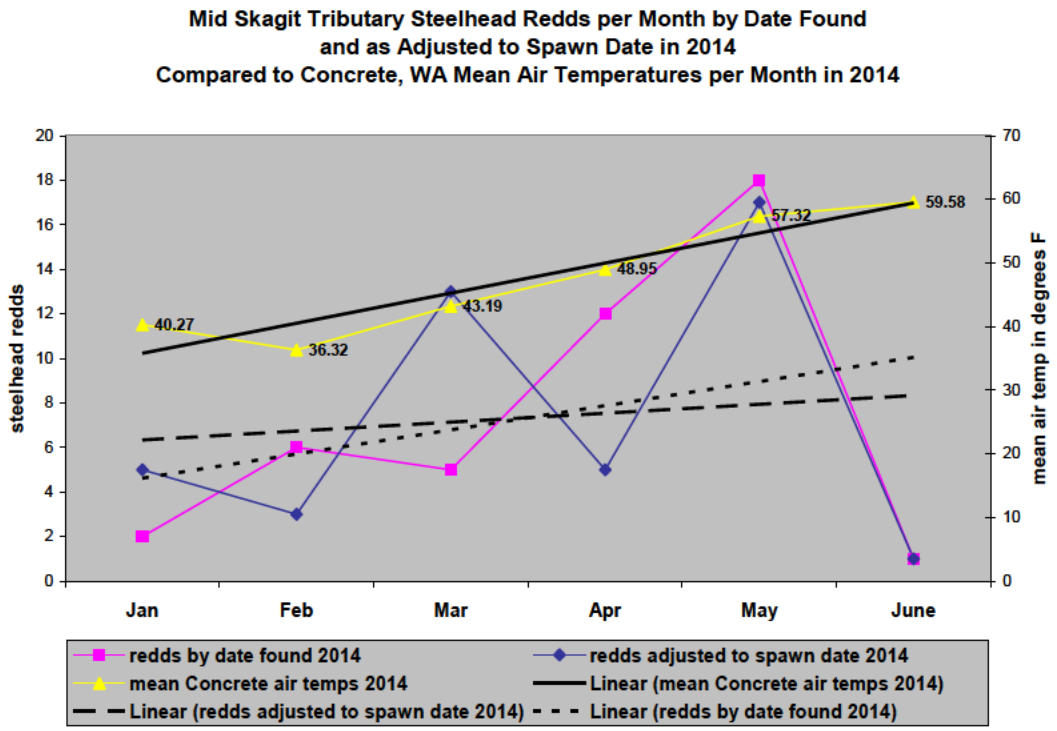
Figure 16.



Pearson's correlation coefficient table. If June is eliminated as the month when only one steelhead redd was found, "r" reverses to + 0.2845, which is also not statistically significant. If February is excluded as the outlier month in the pattern "r" is + 0.9823 and is highly significant, but to exclude February would be to ignore the one month with the greatest steelhead redd count. When the steelhead redd to air temperature correlation is determined after the redds are adjusted to estimated spawning date (Figure 16) for the January to June full spawning period "r" reverses to - 0.7713 and is statistically significant. However, if June is excluded as outside the more typical spawning period "r" is not significant at - 0.6448. Although there is a significant negative correlation of spawning to increased air temperature if redds are adjusted to spawning date and including June, the redds were so limited in June (with air/water temperature increases that limit spawning) that eliminating June is potentially the better evaluation. Given the range of findings, there may be some other relationship that is more primarily driving steelhead spawning than air temperature. Alternatively, the monthly level of temperature to redd date, or to spawning date, comparisons over the 2010-2014 period may not be specific enough to portray the daily temperature variations that could still be a main driver of steelhead spawning.

The steelhead spawning redds adjusted to estimated spawning date at the Mid Skagit tributaries are also compared to mean air temperatures per month at Concrete in 2014 alone (Figure 17). The general trendline for the redds by date found is more similar to that of the mean monthly air temperature trend than when the redd counts are adjusted to estimated spawning date. Nevertheless, the latter trend has a general ascending pattern but the actual spawning occurs in greater peaks and valleys between months. A further evaluation of the relationship of air temperatures to the 2014 steelhead redds as found was made (Figure 18) with a resulting "r"

Figure 17.



of + 0.3230 which is not statistically significant, although if June is excluded (with only one redd found) it results in an "r" of + 0.9060 which is significant. If the 2014 steelhead redds are adjusted to estimated spawning date as compared to mean monthly air temperature (presumably the more appropriate evaluation) it results in an "r" of + 0.1907 which is not significant, and if June is excluded the "r" increases to + 0.7396 but which is still not quite statistically significant (Figure 19).

At the specific tributary level only Finney Creek had enough redds per year in 2010 and 2014 to provide a useful comparison of spawning to air temperature. The redd counts were adjusted to represent the estimated spawning dates in Figure 20 with an apparent increase in spawning as monthly air temperature increased from January through June both years (but spawning only into May). Rather than an even progression spawning occurred in alternating monthly peaks and valleys in 2014 when a particularly cool February with no spawning was followed by a March spawning peak. A second higher spawning peak occurred in May as it warmed after April. In 2010 the air temperatures were more evenly gradual with similarly gradual increases in spawning until a sudden peak in April with little thereafter. During the generally warmer early spawning period of 2010 the peak in mid April was a month earlier than that of mid May in the colder early spawning period of 2014. The Pearson's correlation coefficient for monthly spawning at Finney Creek in 2014 compared to monthly mean air temperature at Concrete resulted in an "r" of + 0.7773 and in 2010 an "r" of + 0.2126. While spawning was positively correlated to air temperatures in the January to May spawning period both years (more so in 2014 than 2010) it was not statistically significant.

The combined comparisons of monthly air temperature correlations to spawning time at the Mid Skagit tributaries are erratic. Without more precise dates when spawning occurs it may limit finding a significant temperature/spawning correlation if there is one (and there apparently is related to initiation and end points). However, stream conditions often deny visibility and the ability to find enough active spawning from which to

Figure 18.

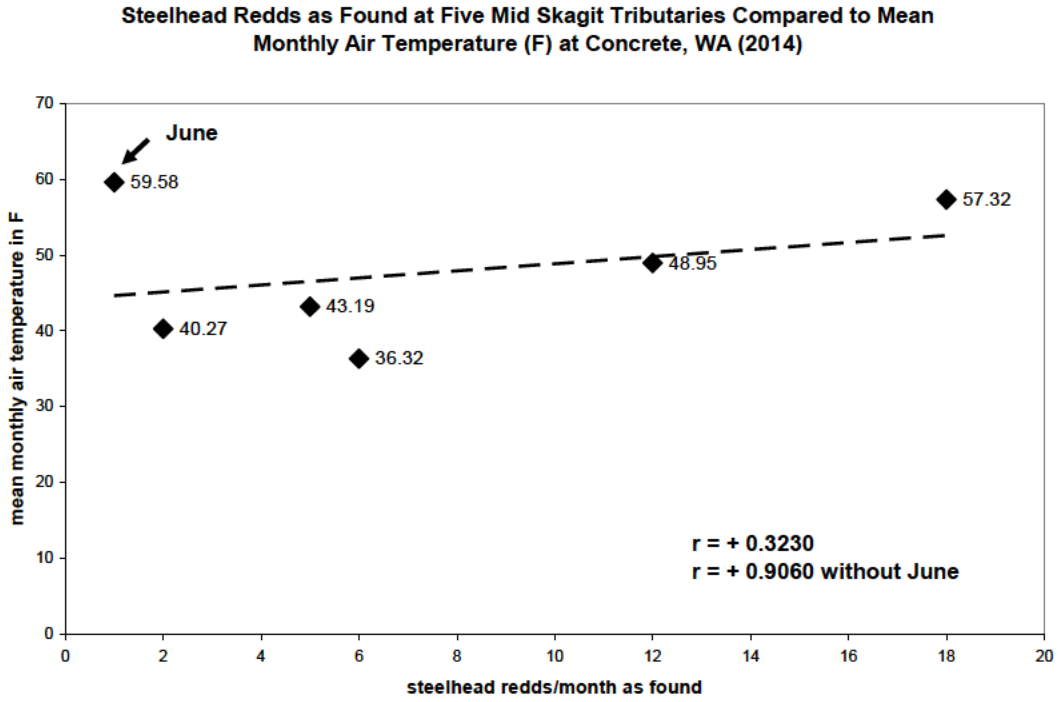


Figure 19.

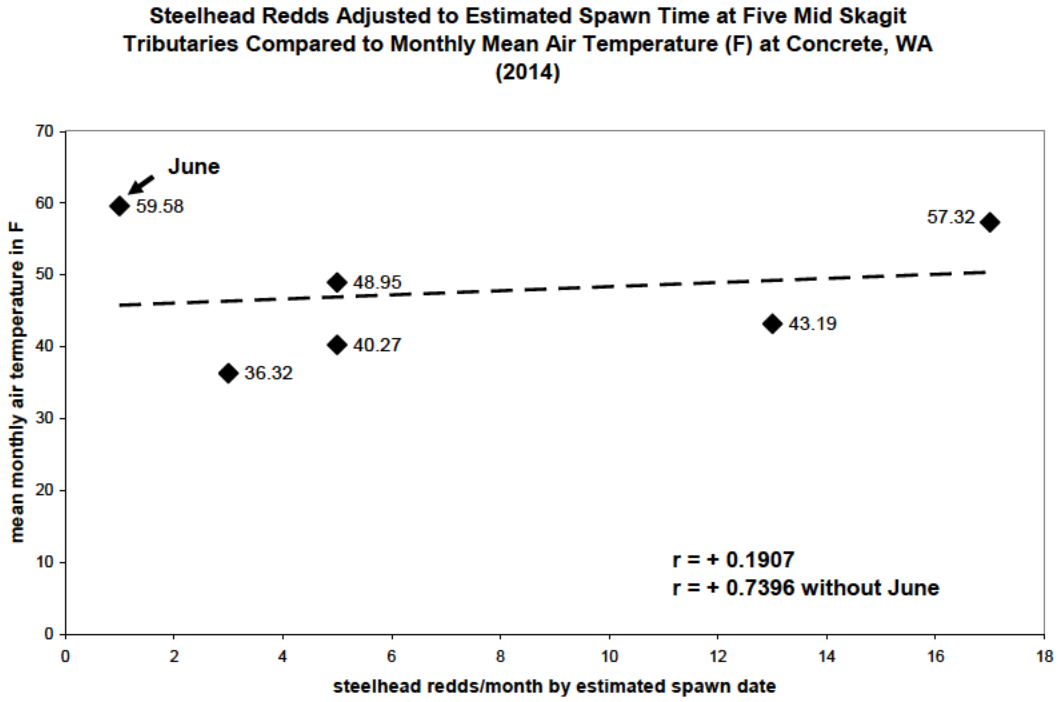
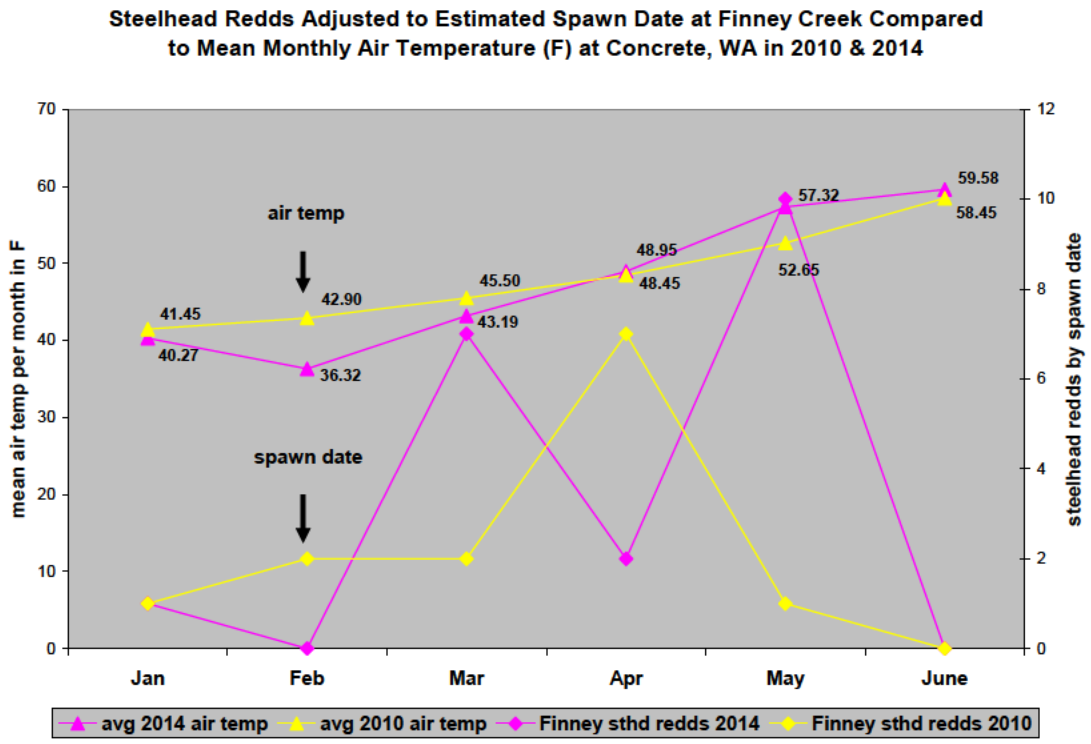


Figure 20.



compare daily temperatures. The Finney Creek shift in peak spawning by 30 days between warmer years and colder years in the early spawning period may well be the most identifiably important temperature relationship. It also concurs with the steelhead spawning survey findings at other Washington rivers (Crawford et al. 1979; Cederholm 1984)) where colder years resulted in later spawning peaks and warmer years in earlier peaks. It also remains that some other factor may be a more consistent driver of steelhead spawning time in the Mid Skagit tributaries, particularly that of intermittent and perennial flows in their selection over time for earlier or later spawning as previously identified.

Precipitation and Streamflow Relationship to Spawning Findings

There are presently no streamflow gages at any of the tributaries surveyed in the Mid Skagit basin, but 1943-48 streamflow records are available for Finney Creek (USGS 1943-48). Streamflow records for 1928-2014 are also available for the North Fork Stillaguamish River (USGS 1928-2014) and have been used by others as a surrogate for Finney Creek (Nichols and Ketcheson 2013). However, Finney Creek streamflows (or those of the North Fork Stillaguamish River) may not necessarily reflect those of the four other Mid Skagit tributary creeks that have shorter lengths, smaller basin sizes, and differing watershed source attributes. Alternatively, monthly precipitation records dating to 1905 are available for Concrete in the Mid Skagit basin (WRCC 2014) that may provide a proxy for streamflow trends, if not the flows themselves, over a long historical period that is more relevant across all five tributaries surveyed. The combination of the 1943-48 streamflow baseline at Finney Creek and mean precipitation per month in the 1909-15 and 1931-2014 time periods at Concrete also provides the opportunity for streamflow considerations related to steelhead spawning based on available comparative trends over time and toward the future.

At the shorter term scale of 2002-14 my rain gage near the mouth of Savage Creek (near Birdsview, Washington) provides the monthly precipitation during the 2010-2014 spawning survey period that is geographically closest to the lower basin areas of the five Mid Skagit tributaries primarily surveyed. The precipitation measures at these two locations from 2010 to 2014 are compared to the steelhead redds by the date found at the Mid Skagit basin tributaries in the same period (Figure 21; Appendix A, Tables 1 and 2 provide the precipitation data per month for Birdsview and Concrete). The precipitation gage near Birdsview is on the south side of the Mid Skagit River near the entry of Savage Creek (RM 45.75) while that of Concrete is on the north side, a short distance up the Baker River (RM 56.5) 10.75 miles (17.3 km) upstream. The five Mid Skagit creeks where the surveys occurred are all on the south side of the Skagit River from O'Toole Creek (RM 43.5) to Finney Creek (RM 47.5) with the Birdsview gage near the middle of the 4 mile length of river that all five tributaries enter. Although the Birdsview precipitation is greater than at Concrete in all months except July and August and may be specifically more accurate for the tributary locations, their pattern of temperatures from month to month are very similar during the steelhead spawning period. As a result, for the purposes of this report the Concrete precipitation data have been used as a surrogate for that of Birdsview because of the longer term history for further comparisons.

The Concrete precipitation is further compared to the redds found at the five Mid Skagit tributaries as adjusted to the estimated steelhead spawning dates (Figure 22) which is the more relevant comparison if the estimated spawning dates more accurately represent the actual spawning time. While it was obvious that a number of redds found were several days to several weeks old, the actual spawning time could only be a best judgment based on amount of algae on the redd, how vague its pit or tailing had become, and the prior periods when there had been spawning in near-by tributaries or otherwise what had seemed the best periods for steelhead entry into these streams.

Figure 21.

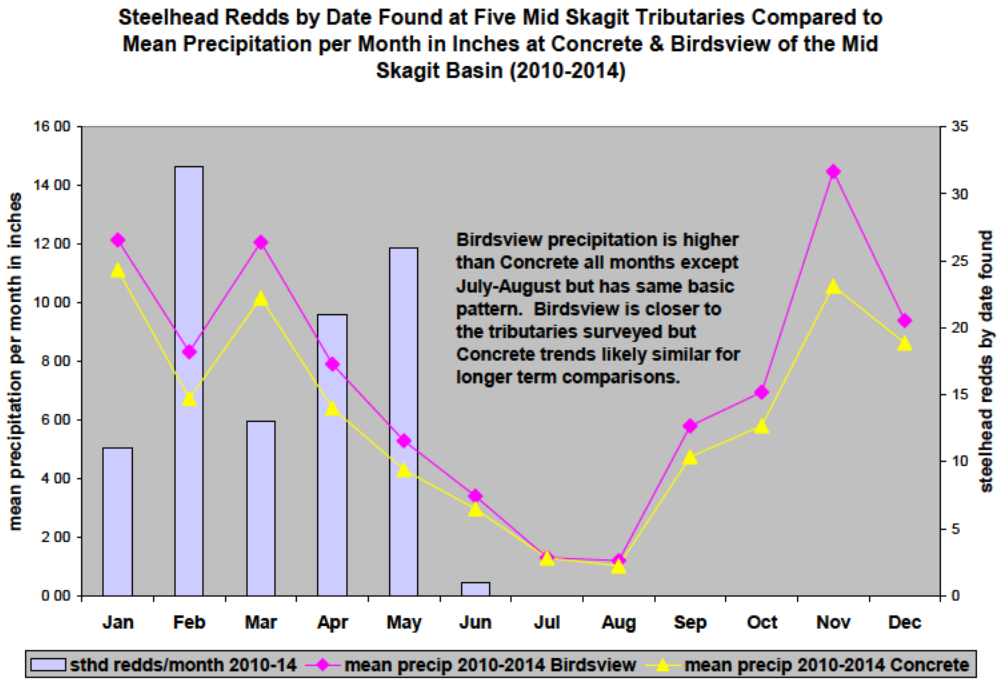


Figure 22.

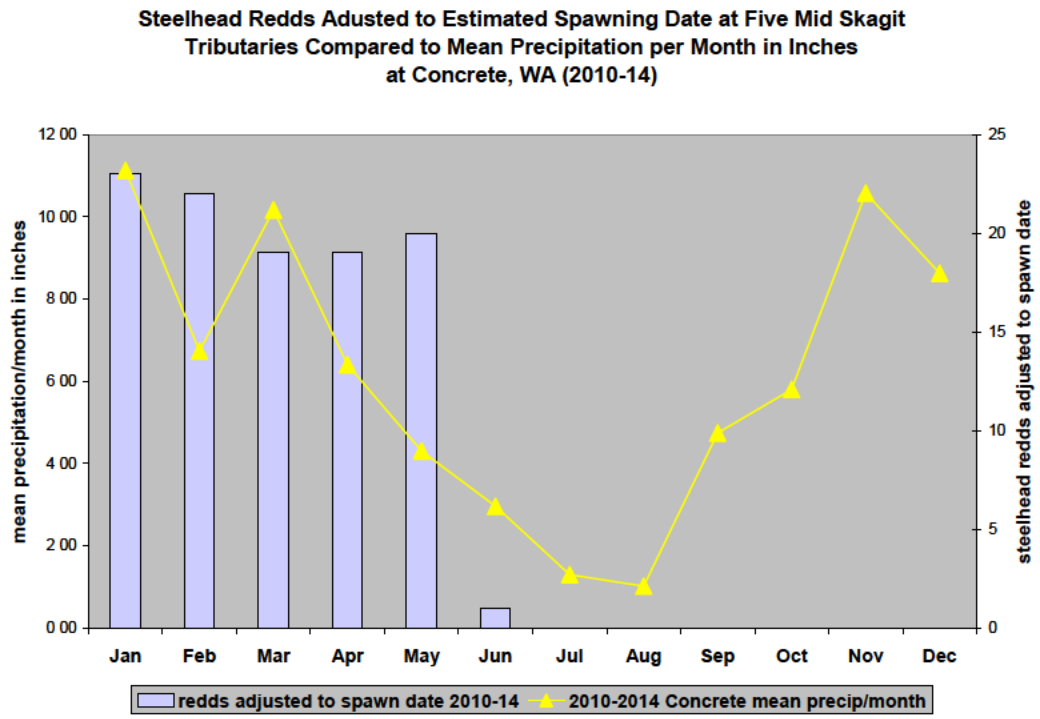
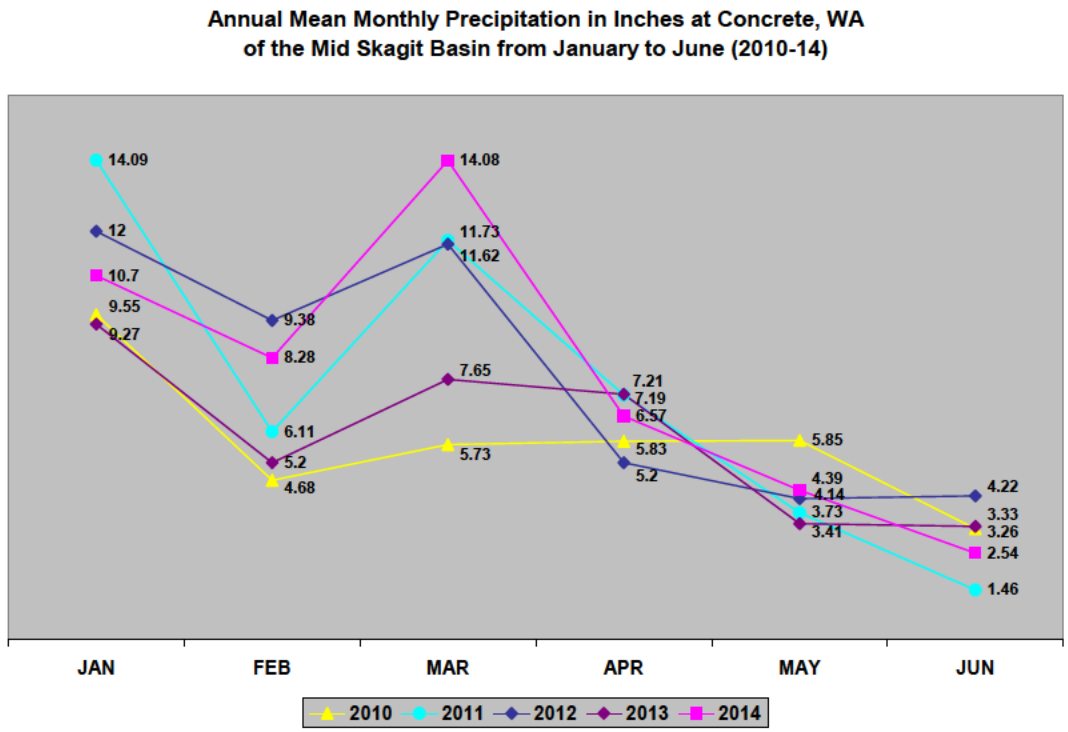


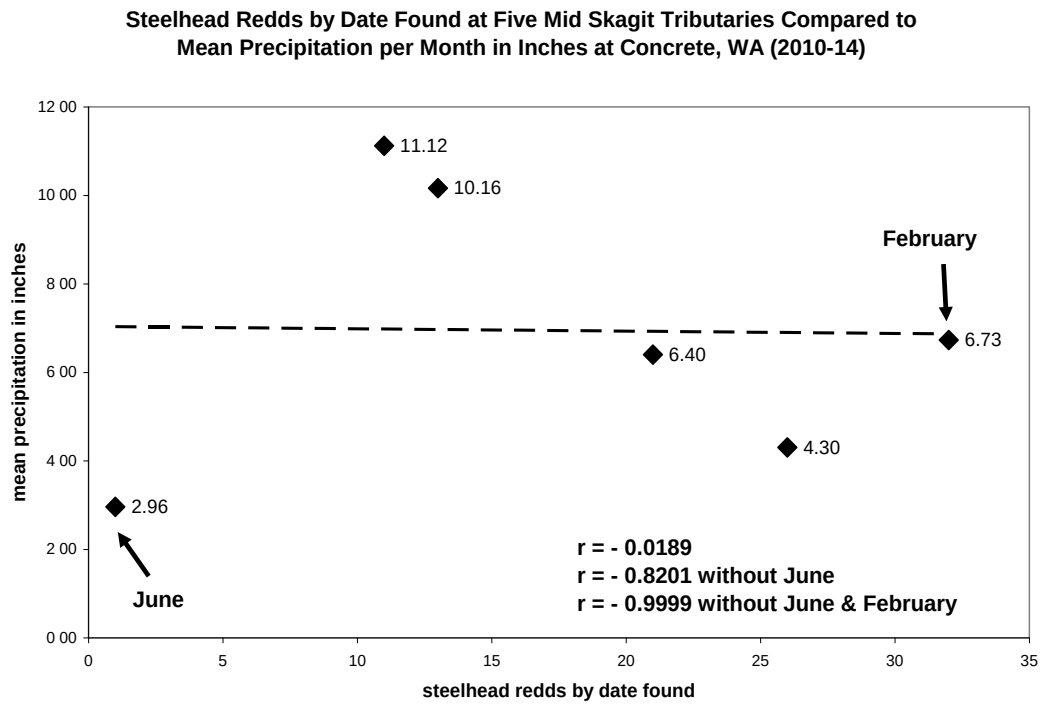
Figure 23.



The mean precipitation per month at Concrete for each year during the complete steelhead spawning period of January to June during the 2010-14 Mid Skagit tributary surveys (Figure 23) had the greatest range in precipitation in March, the smallest ranges in precipitation in April, May, and June, the most precipitation in January and March, and the least precipitation in June.

An evaluation of the relationship of mean monthly precipitation to steelhead redds per month by date found in the full steelhead spawning period from January through June was made with a resulting negative correlation (inverse relationship of precipitation and steelhead redds), or "r", of - 0.0189 (Figure 24). However, this is near zero with little or no correlation. If June is excluded as a month minimally represented in the Mid Skagit tributary spawning findings, the "r" increases to - 0.8201 but it remains a little below what is statistically significant. If February is excluded "r" is - 0.9999 and is highly significant to the point of being for all practical purposes a perfect 1.0. However, as with the temperature considerations, to ignore February would be to ignore the one month with the greatest steelhead redd count. A further evaluation was made of mean monthly precipitation to steelhead redds per month as adjusted to the estimated spawning date in the January through June full spawning period (Figure 25) with a resulting positive correlation (spawning increased with precipitation) and an "r" of + 0.7444 which is below being statistically significant. If June is excluded as the

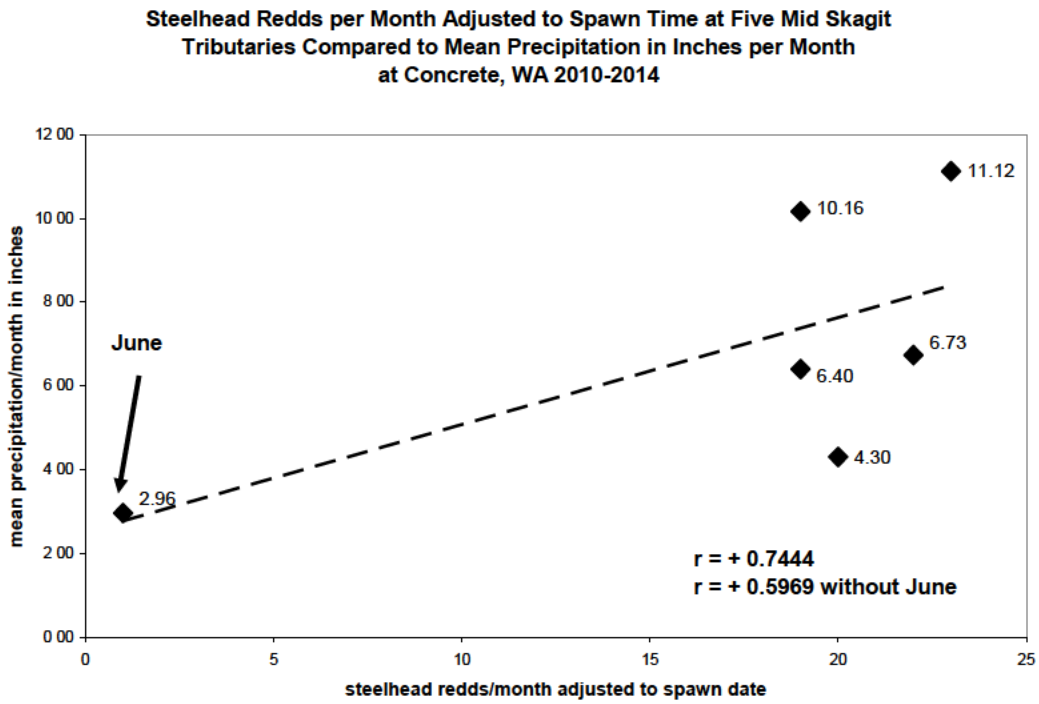
Figure 24.



month least represented in Mid Skagit tributary steelhead spawning "r" decreases to + 0.5969 with even less significance.

Streamflow data from the North Fork Stillaguamish River gage have been used as a surrogate for Finney Creek streamflows (Nichols and Ketcheson 2013). The North Fork Stillaguamish drains the southeast side of Finney Peak. My personal observations over the past 16 years of living near Finney Creek have noted that during high flow event years that Finney often responds more like the streamflows of the North Fork Stillaguamish

Figure 25.



than those for the Skagit or the Sauk rivers from available USGS website data. The mean streamflow per month at the North Fork Stillaguamish from 1943 to 1948 (USGS 1928-2014) can be compared to Finney Creek from 1943 to 1948 (USGS 1943-48) when Finney was gaged, and both of these then compared to North Fork Stillaguamish streamflow during the 2010-14 period when the Mid Skagit tributary spawning surveys occurred (Figure 26). Although the Finney Creek 1943-48 streamflow period has more extreme peaks and valleys than the North Fork Stillaguamish flows in the same period, the patterns of the two are similar regarding how they may influence entry for steelhead spawning and spawning time. The 2010-14 Stillaguamish streamflow pattern (and likely that of Finney Creek) has altered with the former spring peak of May in 1943-48 having shifted to March, two months earlier. The former 1943-48 streamflow valley in March has shifted to February, one month earlier. The historical March valley in spring flow has shifted to a spring peak, a major divergence in pattern that steelhead spawning success must adapt to. The one month of relative stability has been February.

The shift in streamflow patterns can also be compared to precipitation pattern shifts in the same 1943-48 and 2010-14 time periods (Figure 27). As has been established in the prior comparison, 1943-48 mean flows per month for North Fork Stillaguamish & Finney Creek have similar patterns, but it remains that it may not as well reflect the flow patterns of the other Mid Skagit creeks. The precipitation per month at Concrete has greatly increased in January and March with more moderate increases into April and May, but precipitation has not increased in February. Although the precipitation patterns have shifted almost identically to the streamflow patterns in January, February, and March, the 2010-14 streamflow in April has increased at a greater level than the precipitation increase. In the case of Finney Creek and the North Fork Stillaguamish this could be a result of higher elevation snowfall in March that subsequently melts out as much in April as it formerly did with a

Figure 26.

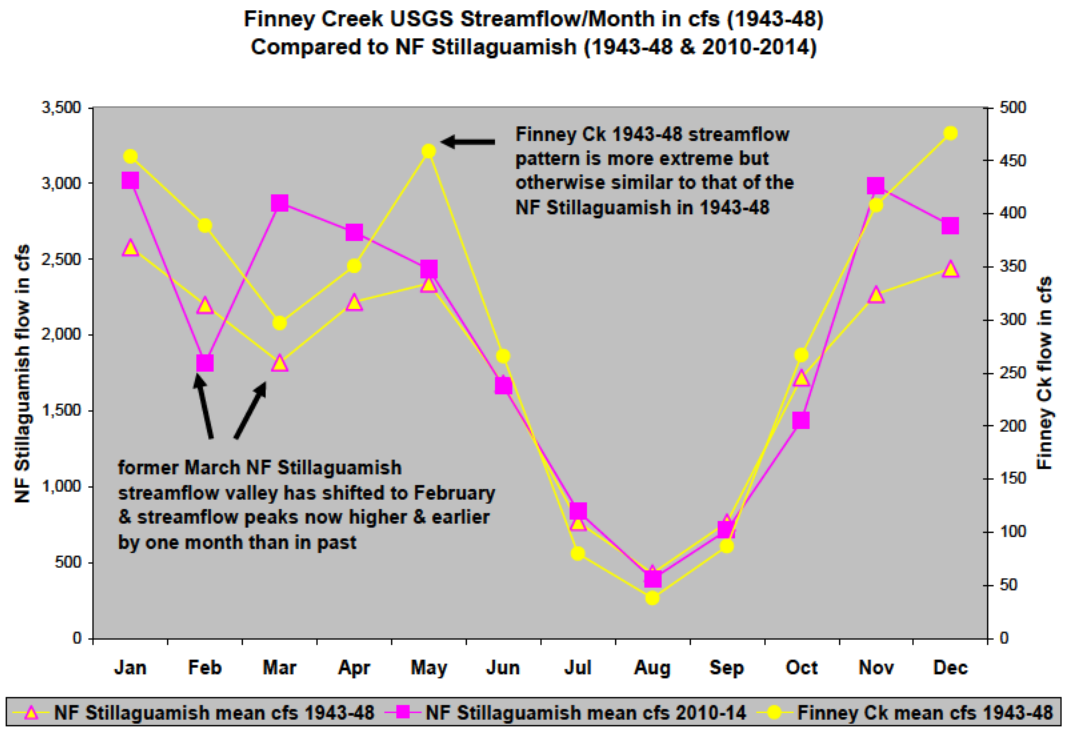
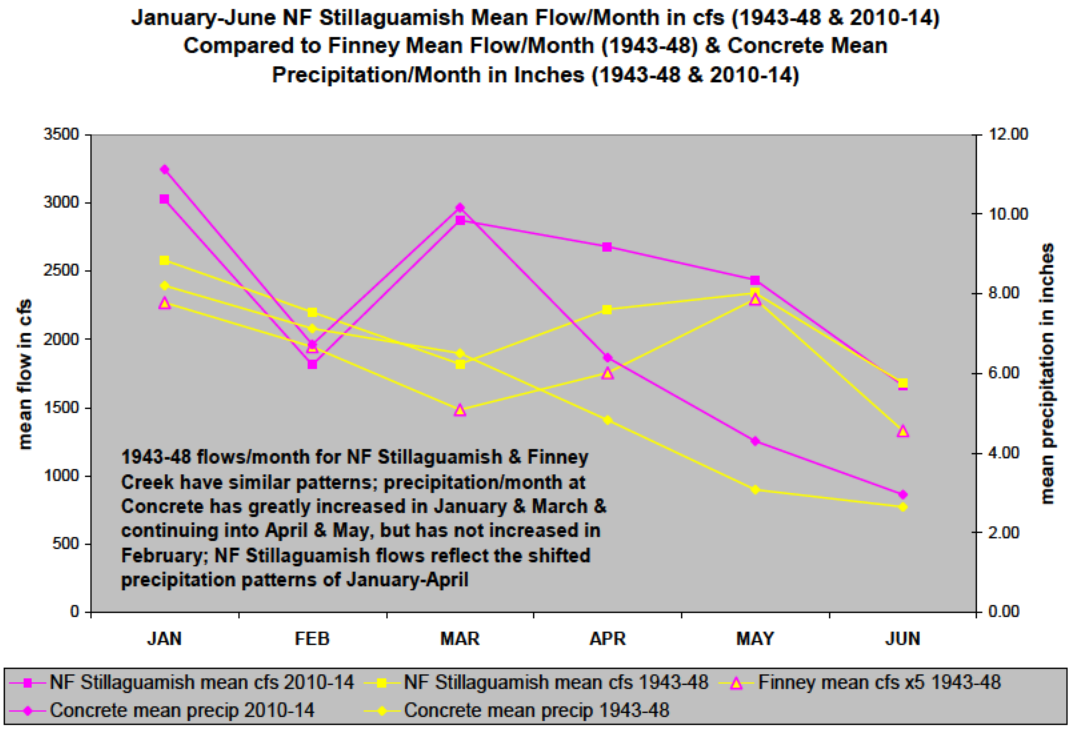


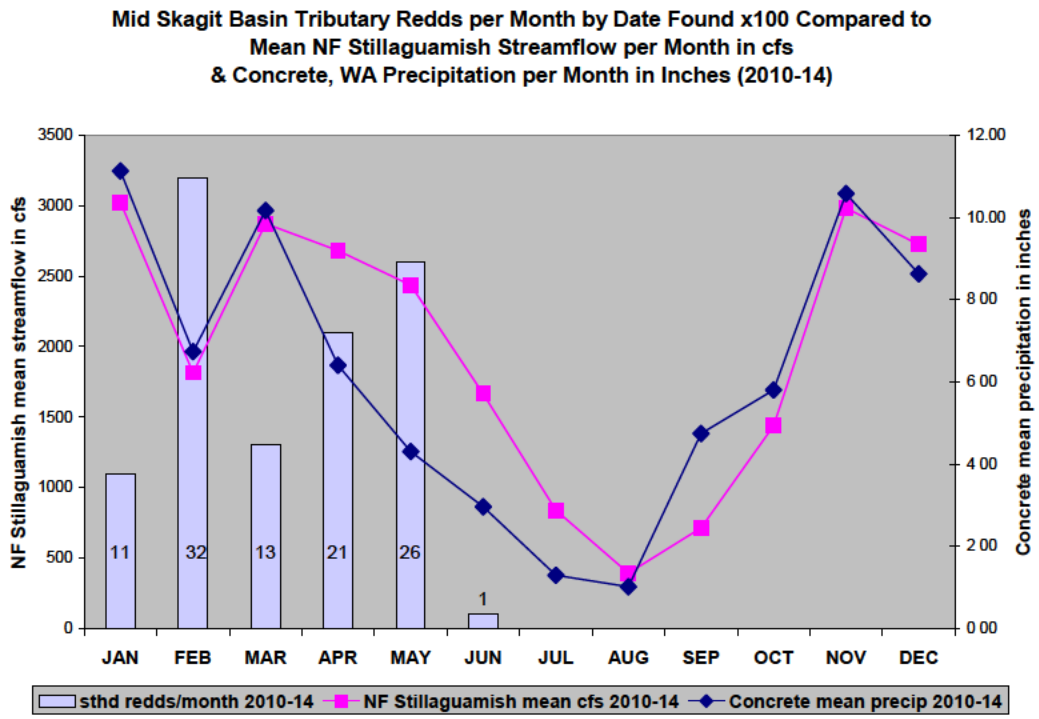
Figure 27.



more singular peak in May. This may, or may not be the case with the other Mid Skagit tributary creeks that are shorter streams with smaller watershed sizes dominated by lower elevation conditions of less snowfall.

The North Fork Stillaguamish mean streamflows per month can be further compared to the mean precipitation per month at Concrete in the 2010-14 time period and to the Mid Skagit tributary redd counts per month (Figure 28). This conveys the convex balloon in NF Stillaguamish streamflow (and likely that of Finney Creek) that now occurs in April, May, and June as compared to the concave pattern of precipitation in the same period at Concrete. The balloon in streamflow, as previously suggested, likely represents increased snowmelt from increasing March precipitation falling as snow at higher elevations. The steeelhead redds found at the Mid Skagit tributaries per month and adjusted to reflect estimated spawning date are portrayed in Figure 29 with resulting differences of spawning time related to streamflow from that of the redd counts Figure 28.

Figure 28.



A comparative evaluation of the relationship of mean monthly streamflow from the North Fork Stillaguamish River to steelhead redds by date found in the January to June full spawning period in the Mid Skagit tributaries was made (Figure 30). It resulted in an "r" of - 0.0391 which is near zero with no correlation of significance. If June with its minimal steelhead spawning is eliminated it results in an "r" - 0.95679 which is highly significant using critical values from the Peaerson's correlation coefficient table. However, if the redds are adjusted to reflect the estimated spawning date as probably the more relevant comparison (Figure 31), "r" reverses to + 0.7836 which is not statistically significant and is less so if June is excluded with an "r" of + 0.6197.

Figure 29.

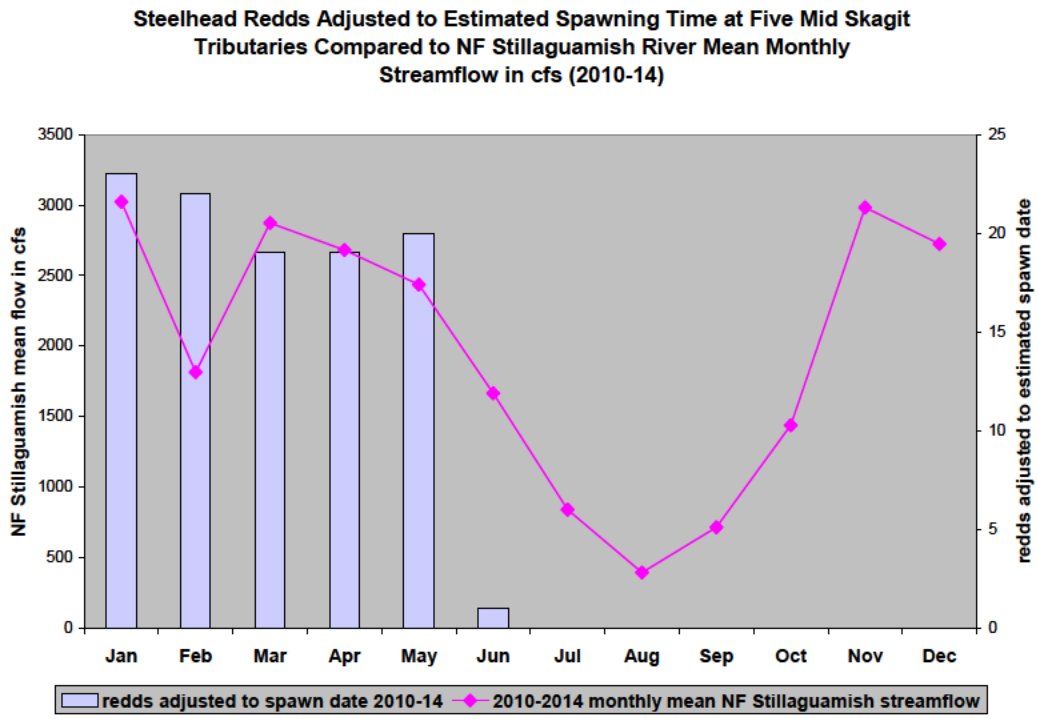


Figure 30.

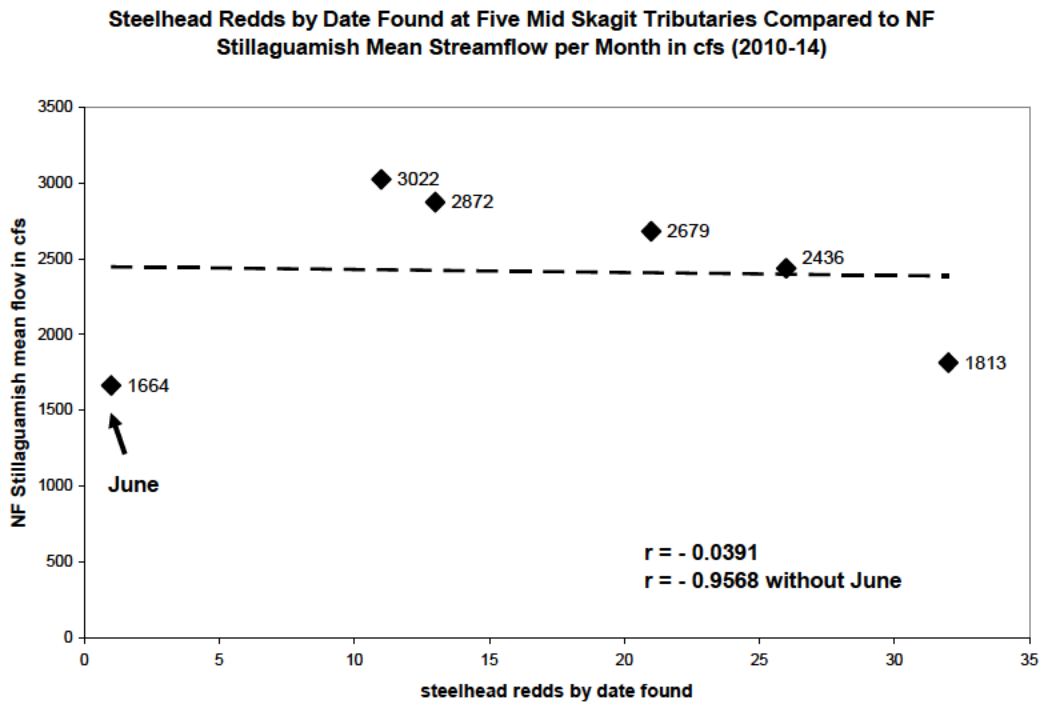
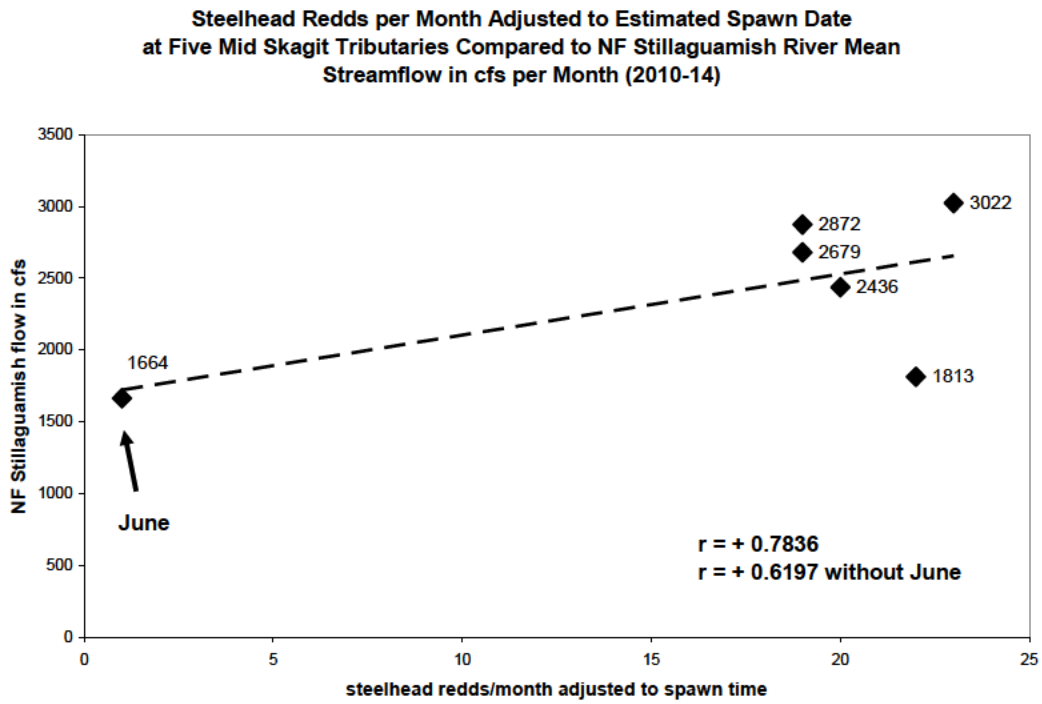


Figure 31.



Intermittent and Perennial Flows

Of particular importance for successful reproduction to the smolt stage is how spring and summer hydrology differences in flow patterns may shape spawn time and fry emergence, particularly the effect of intermittent flows if they regularly occur. Intermittent flows annually occur in the anadromous areas of the mainstems of the following three tributaries regularly surveyed in 2014 (Table 12): Savage Creek, Mill Creek, and Dry Creek. The earliest and latest dates the redds were found is also listed as well as the dates and locations of intermittent flows by tributary if that occurred. At Finney Creek the mainstem remains perennial but side channels used for both spawning and rearing commonly go intermittent. Of the five tributaries regularly surveyed, only O'Toole Creek's entire anadromous length remains perennial. The percentages of spawning that occured in each tributary prior to March 15th (and listed by whether intermittent, parts going intermittent, or perennial) as estimated from redd counts in 2014 and the five year period of 2010-14 are shown in Figures 32 and 33.

Table 12. 2014 Mid Skagit steelhead spawning period differences determined by when redds were found and listed by tributary from earliest to latest, and dates of when stream sections went intermittent if that occurred

Mid Skagit tributary	Time period steelhead redds found	Date & location of intermittency
Savage Ck	January 23-March 15	July 10-13 above pond; Aug 1 below
Mill Ck	April 30	July 10-13 from mouth progressing up
O'Toole Ck	April 7-June 16	Remained perennial
Finney Ck	February 1-May 22	May 30 at numerous side channels
Dry Ck	January 16-May 14	June 24-27 from mouth progressing up

Figure 32.

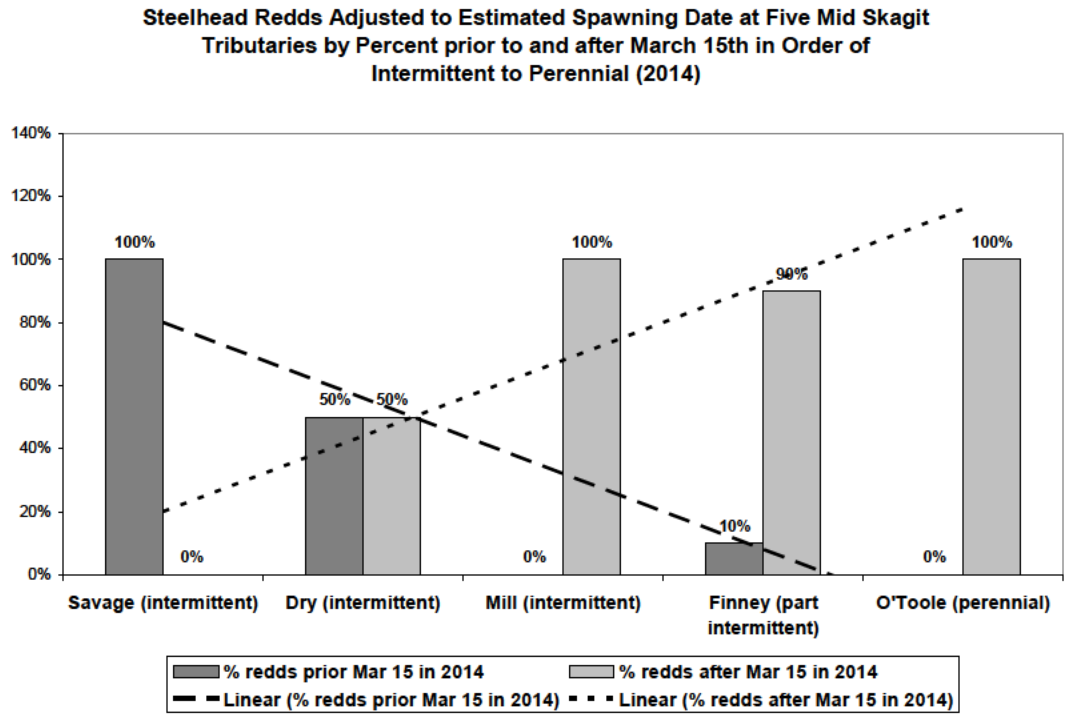
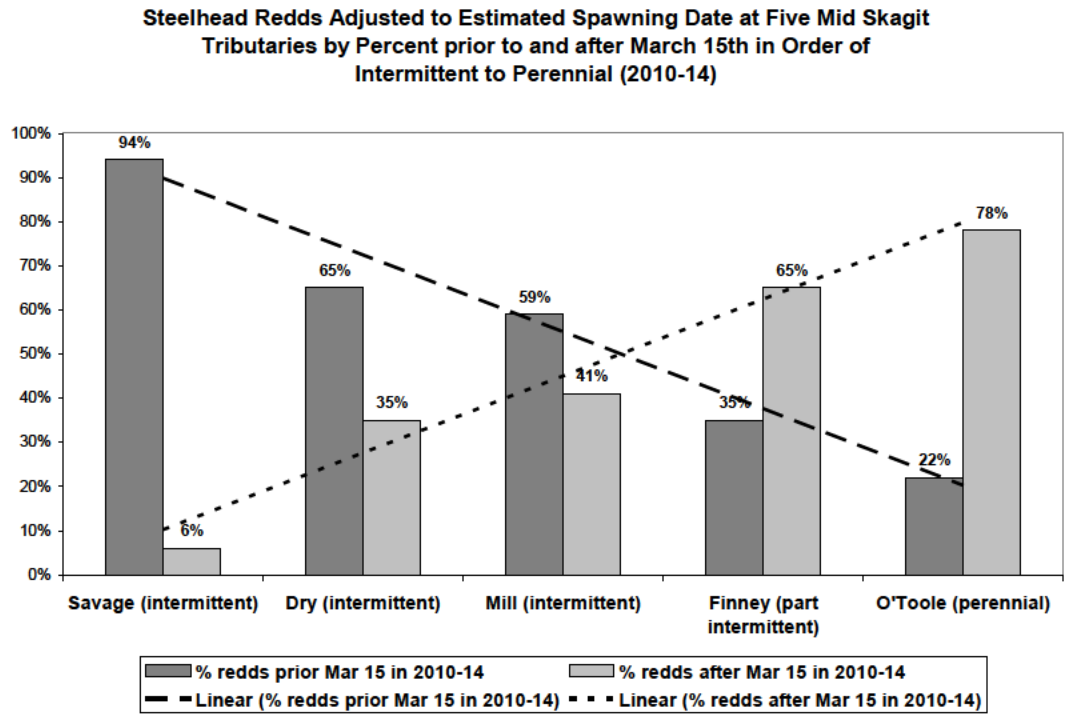


Figure 33.



Although intermittent/perennial flows are but one environmental factor that may shape steelhead spawning time by specific tributary through selective adaptation, the percent of estimated spawning prior to March 15th and thereafter as shown by tributary in 2010-14 (Figure 33) indicates these two hydrology types and the extent of anadromous habitat affected within each tributary, are likely primary drivers of steelhead spawning time. Combining the information from Table 12 and Figure 33 leads to a conclusion that there is a direct relationship between intermittency and percent of steelhead spawning prior to March 15th as indicated by the trendlines at the Mid Skagit tributaries in the five year period of 2010-14. Inversely, the same information leads to a conclusion that spawning primarily after March 15th is related to delay in the area and date of intermittency, and especially to the one stream with perennial flow (O'Toole Creek). At the level of annual variables, as in 2014 (Figure 32), the relationship is not as evident as the more complete data from cumulative years. While intermittency is likely a driving factor of earlier steelhead spawning time, colder early air temperatures in 2014 likely delayed spawning as a factor that can vary more greatly and less predicatively on an annual basis than intermittent or perennial flow patterns (Figure 20).

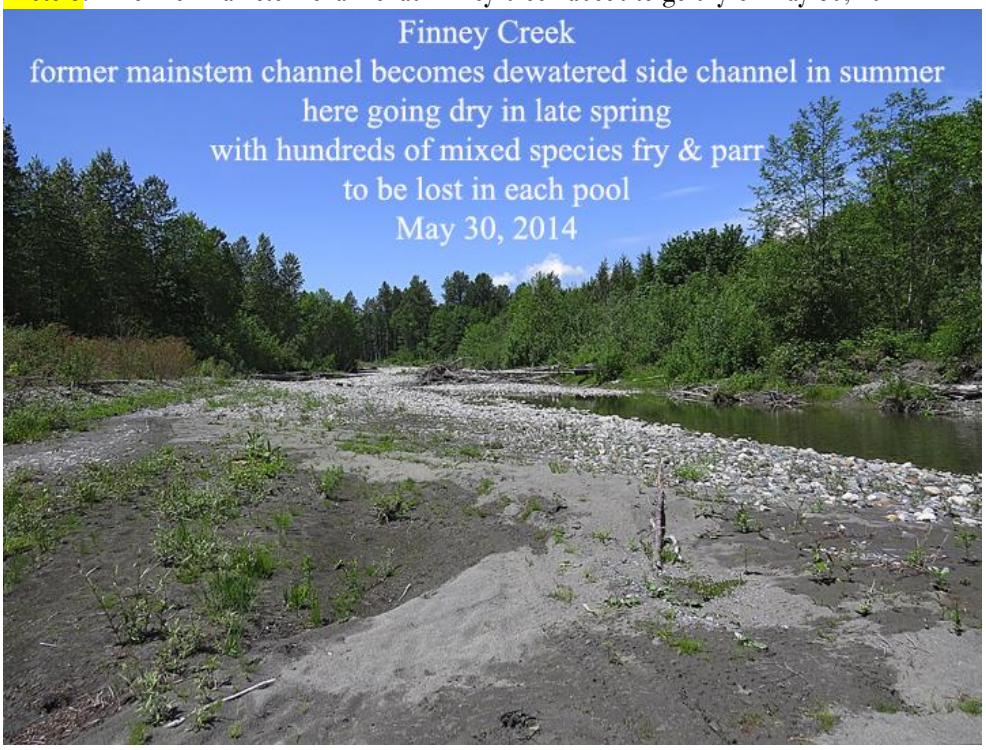
Specific Differences Found by Tributary Regarding Intermittent/Perennial Flow Patterns and Timing

Finney Creek:

Although Finney Creek's mainstem remains perennial there are numerous side channels in the 3.5 km of the 2014 survey reach that go dry even in lower winter/spring flows and increasingly so throughout the summer period. Also, both main channels and side channels can be suddenly vacated during any high flow event due to the unstable nature of its broad channel (Photo 2 and 3). Although juvenile *O. mykiss* movements to the Skagit River are not restricted from mainstem Finney at any time, if side channels are to be effectively used for reproduction the timing of spawning and emergence must fit with the potential for redd dewatering by late May to mid June, or lethal entrapment of emergent fry results with loss of access to the mainstem for escape due to side channels commonly dewatering first at the shallow outlets and inlets.

Photo 2: Finney Creek's continually shifting channel on April 26, 2010, the distant channel now vacated

Photo 3: A former mainstem channel at Finney Creek about to go dry on May 30, 2014



Dry Creek (of lower Finney Creek):

The lower 70-250 m typically goes subsurface by late June to early July. By June 27th of 2014 the lower 70 m had gone subsurface with disconnection from Finney Creek. By July 10th the lower 240 m were subsurface and by July 13th the lower 340 m. Rechecked on August 28th the lower 375-400 m were subsurface. About 525 m above the mouth the gradient significantly increases in transition from the valley floor to the valley wall until anadromous fish passage is blocked by a 6-6.5 m waterfall 870 m from the mouth. This uppermost anadromous reach likely remains perennial most, if not all, years (Photos 4, 5, and 6).

The potential for effective steelhead reproduction given the intermittency pattern at Dry Creek suggests several things. A little over half of the available anadromous stream length remains perennial. If spawning occurs in the lower 400 m the newly emerged fry need to either migrate downstream or upstream prior to that section going subsurface. To go downstream requires fry inclination to do so and an emergence date prior to late June. To go upstream may be denied by significant drops over log sills and boulders of 10-12 inches (25.4-30.5 cm) that newly emerged fry may be incapable of. Steelhead reproduction success in the lower 400 m likely requires spawning to occur that results in downstream emergent fry migration prior to the end of June. By contrast, steelhead reproduction may successfully occur throughout the usual steelhead spawning period if located in the upper 470 m of the anadromous length that remains perennial. However, this provides limited rearing space during reduced summer flows. Greater reproduction success to the smolt stage would be anticipated if a considerable proportion of the fry emerged early enough to outmigrate to Finney Creek (and/or the Skagit River) prior to loss of that opportunity by late June.

Photo 4: Dry Creek's clear flow enters turbid Finney Creek providing conducive entry, March 14, 2014

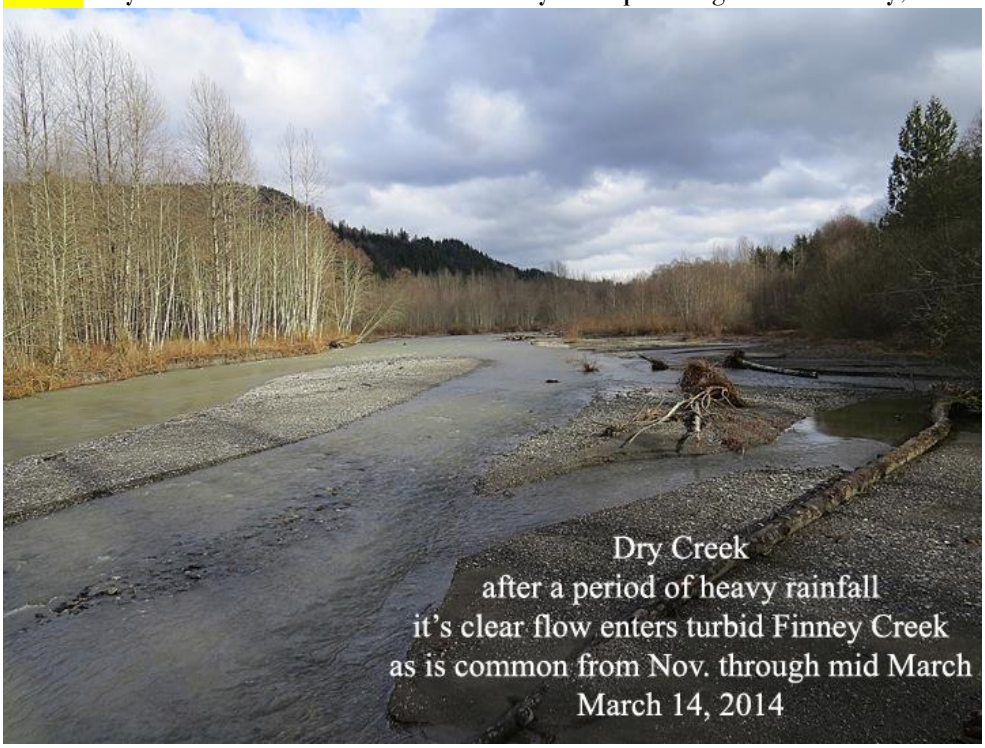


Photo 5: Lower Dry Creek having gone subsurface with disconnection from Finney Creek by June 27, 2014

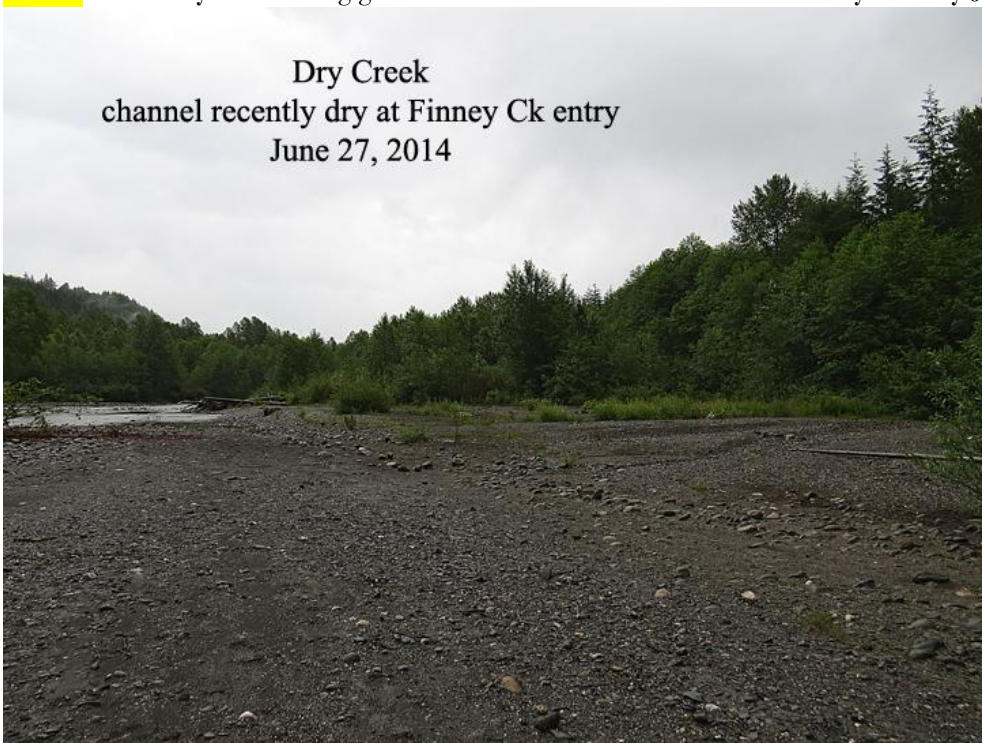


Photo 6: Dry Creek channel still wetted in the 400-500 meters below waterfall barrier, July 10-13, 2014

Mill Creek:

The lower 355 m from the Skagit River entry to the South Skagit Highway commonly goes subsurface by mid

Photo 7: Mill Creek still wetted for 100 m below South Skagit Highway, July 13, 2014

Photo 8: Mill Creek lowermost 300 meters dewatered and disconnected from Skagit River, July 13, 2014

July or early August, except during wetter summers. By July 13th of 2014 Mill Creek's lowermost 250-260 m had gone subsurface disconnecting it from the Skagit River (Photos 7 and 8). In drier summers this subsurface reach can include the lower 400-450 m as occurred by August 28th of 2014. On July 13th the water temperature 90 m above where it went dry was 14.2 C (57.5 F), still healthily cool for rearing.

Successful steelhead reproduction in the lower 250-260 m of Mill Creek depends on spawning that would be sufficiently early for fry to have emerged by early July and either migrate downstream to the Skagit River or upstream to the perennial anadromous reach. The latter is presently limited by a landslide and associated debris about 730 m above Skagit entry preventing upstream passage for fry to a more extensive higher gradient rearing reach above. This presently leaves about 280-480 m for young-of-year rearing for steelhead that spawn in the first 730 m of stream depending on whether summers are drier or wetter. Early outmigration by a significant proportion of the fry would be anticipated to increase productivity to the smolt stage with greater rearing area.

Savage Creek:

This is a more complex watershed that runs through wetlands and ponds (Photos 9, 10, and 11). The lower 1,475 m from the Uppermost Savage Pond outlet to the mouth typically go subsurface by late June to early July with loss of surface connectivity to the Skagit River (personal observations by B. McMillan since 1998). However, when field checked on July 13th of 2014 this prior pattern altered. Despite June of 2014 being slightly drier than normal (Appendix A), and with no July precipitation up to that time, the entire length from Uppermost Savage Pond to the mouth remained wetted with connectivity to the Skagit River. This may have been due to a beaver dam created near the outlet of the upper pond to the ditched section of Savage Creek in the winter of 2013-14 that South Skagit Highway road maintenance left in place rather than removed. The smaller

ponds below the South Skagit Highway go dry by August in all but the wettest summers, but the uppermost pond (Photo 11) remains watered. The uppermost pond has a depth at the deepest point of 13 feet as recently measured in July of 2014 (pers. com. Nora Kammer, Skagit River System Cooperative). Savage Creek from the Uppermost Savage Pond on upstream about 400 m has also gone dry about the same time as Lower Savage Creek disconnecting it from the pond below. The former pattern of going dry remained the same above Uppermost Savage Pond on July 13th. The first 160-185 m above the pond had gone subsurface (Photo 11) and the next 90-100 m would soon do so. These identified portions of Savage Creek that go intermittent above and below the upper pond combine to create a considerable length of stream that is lethal for steelhead fry unless spawning is early enough to result in their migrations to the Skagit River or the upper pond prior to early June.

On July 14th the evening water temperature 450 m above the uppermost pond was 14.4 C (58.0 F), while 135 m below the same pond it was 24.2 C (75.5 F). The evening air temperature was 20-21 C (68-70 F) with a high air temperature at the afternoon peak of 28.3 C (83 F). Numerous coho fry and other unidentified salmonids were sighted at the point below the pond where the 24.2 C temperature was recorded, seemingly healthy and feeding. Salmonid fry were observed throughout the wetted reach 300 to 600 m above the pond but thousands apparently perished in the more than 200 meters that went dry. By the first of August, Savage Creek below the uppermost pond went dry from lack of rainfall after July 13th.

On July 9, 2014, a 24 inch range probable female steelhead kelt was observed in uppermost Savage Pond (pers. com. Nora Kammer and Eric Mickelson, Skagit System Cooperative) during temperature monitoring of the pond. The pond has apparent values for not only juvenile rearing but potential over-summer survival for late spawning steelhead kelts. The last steelhead redd was observed at a fork of upper Savage Creek on March 15th (Appendix C) and may have been created by the female sighted in the pond downstream on July 9th.

Photo 9: Mid Savage Creek during flow conditions conducive to upstream migration, March 7, 2014

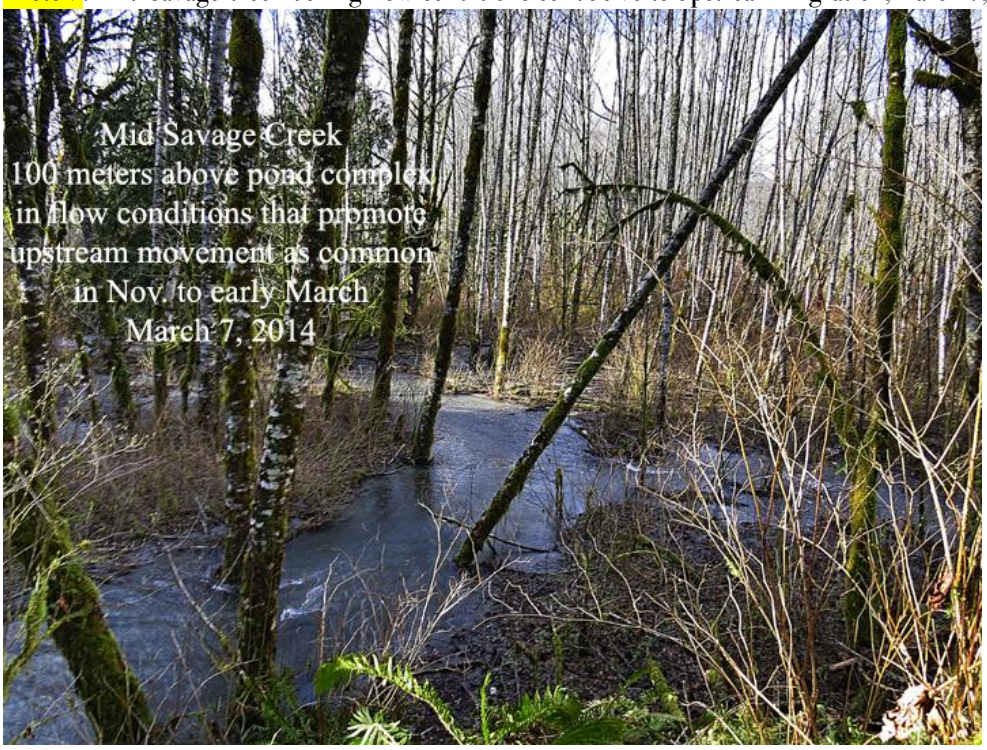
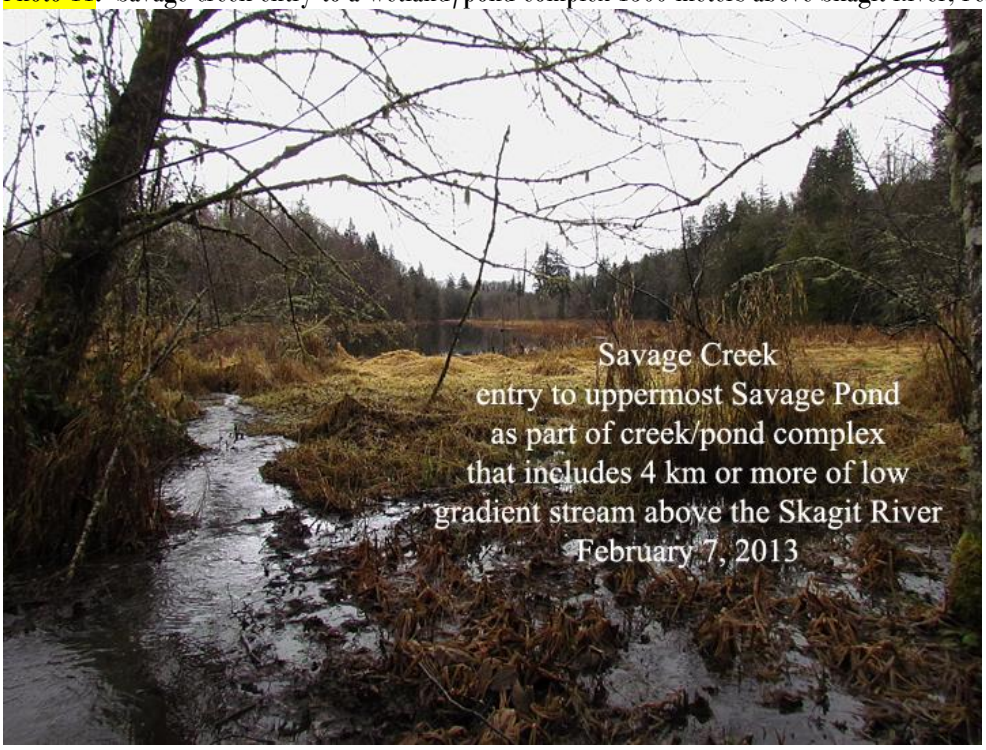


Photo 10: Savage Creek at same point as Photo 10 but looking upstream at dry channel, July 13, 2014

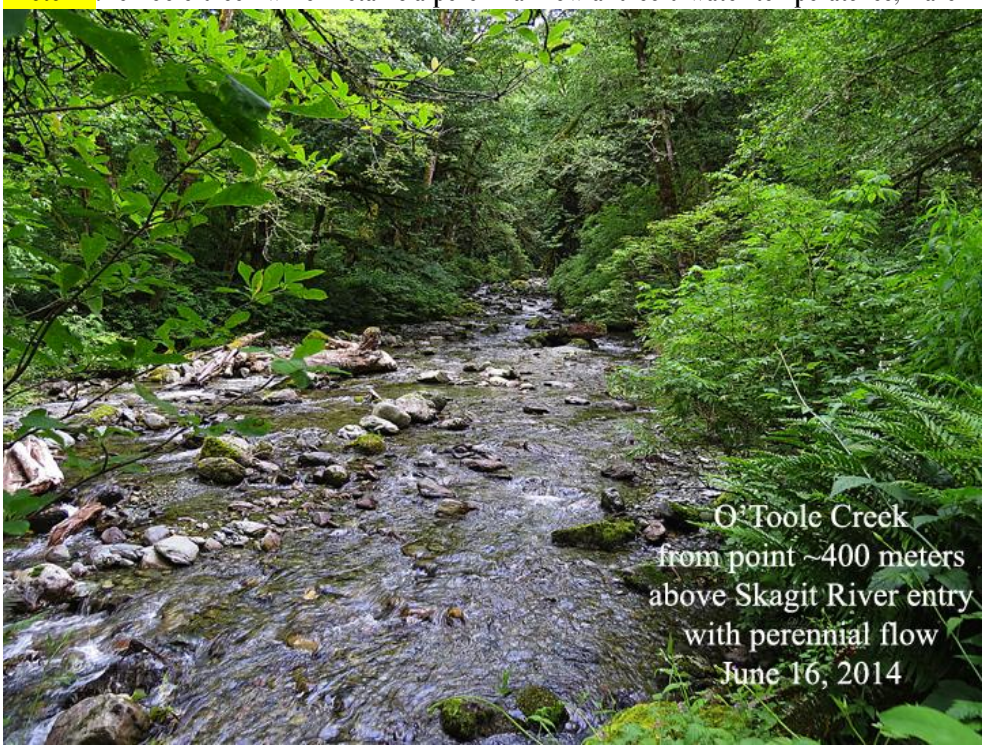
Photo 11: Savage Creek entry to a wetland/pond complex 1500 meters above Skagit River, February 7, 2013



O'Toole Creek:

The entire anadromous length of 620 m to the barrier falls is perennial. As depicted (Photo 12), O'Toole Creek

Photo 12: O'Toole Creek which retains a perennial flow and cold water temperatures, March 14, 2014



has a larger substrate and higher gradient in its lower reaches than the other four streams regularly surveyed. It has a minimal gravel deposition bar at its entry to the Skagit River and throughout the year juveniles have access to the mainstem river with no constraints on steelhead fry movements after spawning. When field checked on August 16, 2014 its water temperature at 3:20 pm was 59 F (15.0 C) with an air temperature of 69.5 F (20.8 C). Both winter and summer it often has the coldest water temperatures measured of the five Mid Skagit tributaries regularly surveyed for steelhead spawning.

O. mykiss Fry Emergence Time and Presence of Other *O. mykiss* Ages

Related to streams being perennial or intermittent, stream checks at the end of the spawning survey season occurred from mid May to mid June to determine when fry emergence was occurring. Photographs were taken using a small underwater camera mounted on a four foot long pole as previously described. The camera was set to take photos automatically at 5-second intervals at varied points under the stream surface to try to determine at what date steelhead fry emergence was occurring prior to going dry and if there was time for fry migration to perennial flow areas within the same stream or to the mainstem the creek was tributary to. The presence of other species of fry was also determined as well as life histories other than fry. The photographs were examined to determine the presence of *O. mykiss* fry and other *O. mykiss* ages present. This entailed enlarging the photographs on a computer monitor to the limits that the resolution of the digital photos allowed from which to

attempt making species distinctions. The underwater camera needed for this was not available until May 12th and may have resulted in missing earliest *O. mykiss* fry emergence. The earliest fry positively determined to be *O. mykiss* were photographed on May 30, 2014 at both Finney Creek and Dry Creek of Finney Creek (Photos 13 and 14). Potential *O. mykiss* fry mixed with coho fry were photographed at lower Dry Creek on May 16th and 21st. Those of May 16th were either large young-of-year (YOY) or very small age 1-plus *O. mykiss* (estimated 40-45 mm), and the photos of May 21st were too low resolution to positively identify as *O. mykiss*. Juvenile salmonids observed in Mid Skagit tributary streams from January 5th to July 10th of 2014 are listed in Table 13 which includes all species and above surface observations.

Table 13. Mid Skagit Basin Tributary Juvenile Salmonid Life Histories Observed by Date in 2014

Creek (section)	Date	Species, life history, & estimated size in mm	Abundance	Method of observation
Savage (lower)	1/5/2014	unknown species; large fry; 35-55mm	50 moving downstream	above surface visual
Savage (lower & mid)	4/19/2014	coho; fry; 20-30mm	dozens	above surface visual
Dry (lower)	5/2/2014	coho; fry; 20-30mm	dozens	above surface visual
Dry (mid)	5/14/2014	O. mykiss; likely 1-plus; 60-100mm	2-3	underwater photos
O'Toole (upper)	5/15/2014	O. mykiss; 1- & 2-plus; 100-175mm	3	underwater photos
Dry Ck (lower)	5/16/2014	O. mykiss; fry or small 1-plus; 40-50mm coho; fry; 25-40 mm	a few scattered dozens	underwater photos
Hatchery (lower)	5/16/2014	O. mykiss; 1- to 2-plus; 100-125mm	2	underwater photos
Dry (lower)	5/21/2014	O. mykiss; fry or small 1-plus; 40-50mm O. mykiss or clarki; 1-plus; 100-125mm coho; fry; 25-40mm	a few scattered 1 dozens	underwater photos
Mill (mid)	5/22/2014	O. mykiss; 1- to 2-plus; 100-150mm coho; fry; 25-35mm	5-6 10-15	underwater photos above surface visual
O'Toole (mid)	5/22/2014	O. mykiss; fry or small 1-plus; 40-50mm O. mykiss; likely 1- 2-plus; 100-150mm	2 5	underwater photos
Dry (lower & mid)	5/30/2014	O. mykiss; fry; 20-30mm coho; fry; 25-50mm	a few scattered hundreds; some moving downstream	underwater photos
Lower Finney (side channel pool going dry)	5/30/2014	O. mykiss; fry; 20-30mm coho; fry & parr; 25-70mm Chinook fry; 30-35mm chum fry; 30-35mm	a few scattered 100-200 10-12 2-4	underwater photos
Dry (lower)	6/6/2014	O. mykiss; fry; 25-35mm O. mykiss; 1- 2-plus; 60-150mm coho; fry; 25-40mm	a few scattered 5-6 many hundreds	underwater photos
Dry (lower)	6/17/2014	O. mykiss; fry; 20-35mm O. mykiss or clarki; 1- 2-plus; 100-175mm coho; fry & parr; 25-70mm	6-10 3 many hundreds	underwater photos
Lower Finney (side channel pool nearly dry) Lower Finney mainstem	6/17/2014	O. mykiss; fry; 20-35mm coho; fry & parr; 25-80mm Chinook fry; 30-40mm coho; parr; 60mm	5-6 100-200 5-6 1	underwater photos
Dry (lower – going dry) Dry (mid) Dry (upper)	6/27/2014	O. mykiss; fry; 20-30mm coho; fry & parr; 25-70mm O. mykiss; fry; 20-30mm O. mykiss; 1- 2-plus; 100-150mm coho; fry & parr; 25-70mm O. mykiss; fry; 20-35mm O. mykiss; 1-plus; 90-125mm coho; fry; 30mm	dozens hundreds dozens 2-3 hundreds few dozen 2-3 2-3	underwater photos
Dry (lower) Dry (mid) Dry (upper)	7/10/2014	O. mykiss; fry; 20-40mm O. mykiss; 1- 2-plus; 80-150mm coho; fry & par; 25-70mm O. mykiss and/or clarki; fry; 20-35mm O. mykiss or clarki; 1- 2-plus; 80-150mm coho; fry; 25-40mm O. mykiss and/or clarki; fry; 20-35mm O. mykiss or clarki; 1- 2-plus	dozens 3-4 many hundreds few hundred 3-4 hundreds many dozens 5-6	underwater photos

O. mykiss of ages 1-plus and probable 2-plus were photographed from May 14th through July 10th at Mill, O'Toole, and Dry creeks of those streams regularly surveyed, and at Hatchery Creek of those infrequently surveyed. The July 10th underwater photographs taken at Dry Creek were the last taken as it was progressively dewatering in an upstream direction leaving a dry stream channel where an estimated several thousand combined juvenile coho, *O. mykiss*, and *O.clarki* perished within the space of 3-4 days. Despite digging down into the gravel at several locations after dewatering no evidence of any fry or parr was found.

Of the five Mid Skagit tributary creeks of survey emphasis, four are known to be subject to intermittent flows in portions of their steelhead spawning areas: Mill, Savage, Dry, and Finney. Dry Creek is the most predictable and extreme of those with intermittent flows, and yet sustains considerable wild steelhead spawning. Each year it begins to go subsurface by latter June to early July with an initial disconnection from its entry to Finney Creek in the lowermost 100 m with a progression of dewatering that continues upstream another 300-400 m, or about half of its 0.85 km anadromous length.

No water temperature data were taken in 2014 with the needed frequency to determine how the dates of the *O. mykiss* fry sightings may relate to their date of egg deposition/fertilization. However, Table 14 provides the ranges of hatch times per water temperature found in the published literature. From that table, steelhead fertilization to fry emergence at 5 C (41 F) would be about 94-101 days (Wales 1941). At 5.5 C (41.9 F) Hardy (2002) indicates a similar period of time if 2-3 weeks is used for hatch-to-emergence. At 10 C (50 F) there is a range of 35-50 days indicated for fertilization to hatch time (Hardy 2002; Shumway et al. 1964; and Wydoski and Whitney 1979) and if the 2-3 week hatch-to-emerge time is used it would indicate 49-71 days. Given the mid January to mid May period of time when steelhead spawning was found at Dry and Finney creeks, a water temperature range of 5-10 C (41-50 F) and subsequent 49-101 days for fertilization to fry emergence provides a reasonably good fit based on the photographic evidence of fry presence in 2014.

Table 14. *O. mykiss* fertilization-to-hatch, hatch-to-emerge, and total emergence times found in literature

Temp	Days to hatch	Days to emerge	Total days to emerge	Reference
2 C (35.6 F)	115	....	....	Quinn 2005
5 C (41 F)	68	....	....	Quinn 2005
8 C (46.4 F)	42	....	....	Quinn 2005
11 C (51.8 F)	28	....	....	Quinn 2005
14 C (57.2 F)	22	....	....	Quinn 2005
5.5 C (41.9 F)	80	....	....	Hardy 2002
10 C (50 F)	31	20	51	Hardy 2002
15 C (59 F)	19	10	29	Hardy 2002
10 C (50 F)	35 *	....	....	Shumway et al. 1964
5 C (41 F)	80	2-3 weeks	94-101	Wales 1941
15 C (59 F)	19	2-3 weeks	33-40	Wales 1941
10 C (50 F)	50	....	somewhat later	Wydoski & Whitney 1979

* Dissolved oxygen considerations from Quinn 2005: decreased O2 delayed hatching at 10 C (50 F) from about 35 days to 40 days in steelhead as cited from Shumway et al. 1964.

Using Table 14 as a guide, the hatchery female steelhead digging a redd with a wild resident *O. mykiss* male on January 16th would result in fry emergence between April 20 to April 27 if the average temperature was 5-5.5 C (Wales 1941; and Hardy 2002). For the wild steelhead sighted on February 19th, fry emergence at that same average temperature would be May 24 to May 31. The possible sighting of *O. mykiss* fry on May 16th, as

occurred at Dry Creek, would be well within the time required from the earlier spawning that was observed. Even earlier emergence is a consideration depending on weather/temperature variables each year, and this could explain the potential *O. mykiss* fry of 40-45 cm, rather than being very small 1-plus aged *O. mykiss*.

Photo 13. *O. mykiss* fry at Dry Creek of Finney Creek, May 30, 2014

Photo 14. *O. mykiss* fry at Finney Creek side channel, May 30, 2014

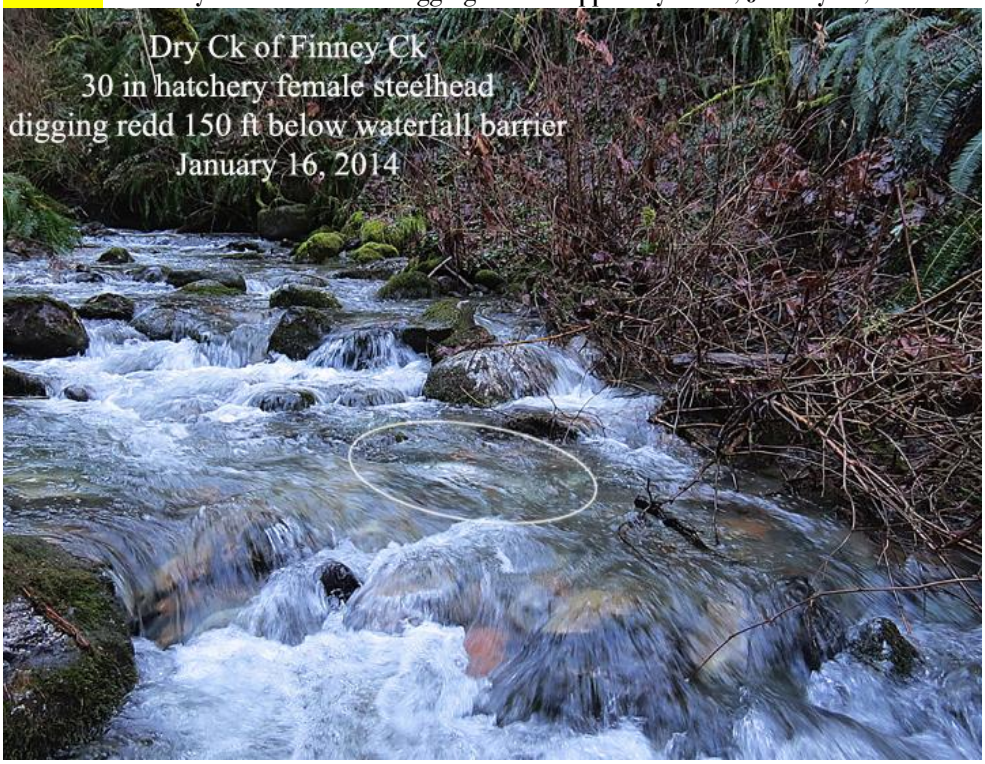
At Savage Creek, numerous coho fry were visually identified without a camera by at least April 19th of 2014. At Dry Creek, many coho salmon fry were observed by May 2nd of 2014. On January 5th of 2014 a school of about 50 juvenile salmonids of an estimated 35-55 mm in length were observed moving downstream at Savage Creek below the upper two ponds about 830 yds (0.76 km) from its entry to the Skagit River. Their size was seemingly too large to be the out-migrating fry of pink salmon that spawned in considerable numbers the previous fall in Savage Creek, and seemingly too small and too early to be coho smolts leaving the ponds. The schooled downstream movement did not seem a likely trait of *O. mykiss* or *O.clarki* parr either. A downstream movement of similar sized salmonids was observed the previous year about the same time at Savage Creek. It was considered that it may be characteristic of one of the salmonid species that uses the ponds for part of its life history and then moves into the Skagit at the peak of winter. There is also a large pond midway downstream to the Skagit River. Perhaps the fry migrate between the ponds to take advantage of some advantageous condition of one over the other. Alternatively, there may have been a prior migration of the same juvenile salmonids from the Skagit River that moved upstream into the creek and ponds for warmer and more stable conditions in the fall than provided by the mainstem river followed by a winter outmigration back again. For whatever reason, it provides an example of the differences individual tributary characteristics can have on salmonids in apparent deviations from what are considered more typical life history patterns.

Discussion

Wild, Hatchery, and Resident *O. mykiss* Spawning Mix in Mid Skagit Tributaries

At the five tributaries of the Mid Skagit basin regularly surveyed in 2014 steelhead spawning began by at least January 16th. At that date a hatchery female steelhead (missing adipose fin) of an estimated 30 inches (76.2 cm)

Photo 15. Hatchery female steelhead digging redd at upper Dry Creek, January 16, 2014



was paired with a wild male resident *O. mykiss* of an estimated 15 inches (38.1 cm). Of particular significance, this spawning activity was observed less than 50 m below the uppermost limit of anadromous migration determined by a 4-5 m waterfall in a tributary of a tributary of the Mid Skagit basin (Photo 15). This indicates there is likely no accessible area within the tributaries of the Mid Skagit basin where hatchery steelhead have not penetrated through straying and where feral spawning has taken place that includes with wild steelhead and/or wild resident *O. mykiss* males. The resident male life history, and/or mature male parr, of *O. mykiss* are an important part of the overall spawning population of a number of steelhead populations throughout their geographic range (Needham and Taft 1934; Savviatova et al. 1973; Seamons et al. 2004; McMillan et al. 2007; Christie et al. 2011).

The first wild steelhead (with adipose fin) was observed on February 19th at upper Dry Creek just 25 m below the barrier falls and within 25 m of where the hatchery female had created its redd a month earlier. Although redd digging was not occurring, and spawning was potentially completed, the wild female (estimated 23 inches, 58.4 cm) was still being vigorously attended by a male steelhead (estimated 24 inches, 61 cm) of undetermined origin (adipose presence could not be determined) in apparent competition with a smaller male. The smaller male (estimated 17 inches, 43.2 cm) was likely a sea-run cutthroat found mated in active spawning with a female sea-run cutthroat (estimated 15 inches, 38.1 cm) near the same location the following day. Although it could not be determined if the wild male sea-run cutthroat had spawned with the wild female steelhead, or if it was present primarily to feed on eggs, it is well documented that hybridization between steelhead and cutthroat occurs in similarly small streams (Taylor 1997; Campton and Utter 1985).

What became evident in the 2013/14 spawning surveys regarding *O. mykiss* is that the spawning grounds of even very small tributaries of the Mid Skagit basin are complex places that include feral spawning hatchery steelhead, hatchery/wild *O. mykiss* spawning interactions at multiple life history levels, and that there is not only probable natural hybridization between steelhead and sea-run cutthroat, but that it may also include wild sea-run cutthroat hybridization with hatchery steelhead. Although the lattermost case was not observed, the spawning presence of time and place by both closely coincided.

It is clear from the Mid Skagit tributary surveys that significant amounts of steelhead spawning occur at or prior to March 15th, but this was less so in 2014 (27%) than for the cumulative 2010-2014 period (49%). Past survey protocols commonly used have been unable to account for this early steelhead spawning due to rarely, if ever, performing surveys on these streams prior to March, or more commonly March 15th. The recent exception to this has been the initiation of February surveys in the upper anadromous section of Finney Creek to determine what is thought to be largely summer steelhead spawning there (pers. com. Brett Barkdull of WDFW). Regarding how much of the early spawning is by hatchery steelhead or wild is limited to making careful observations of active steelhead spawning and resident *O. mykiss* life history mixes. In the 2014 surveys, five incidences of female steelhead associated with spawning redds were encountered with observations and photographs made between January 16th and May 12th (Table 8). The observed spawning participants were composed of 10 anadromous *O. mykiss* life history steelhead (76.9%), two resident life history *O. mykiss* (15.4%), and one sea-run cutthroat (7.8%). Their species, life history, sex, and origin were: 3 wild female anadromous *O. mykiss* (23.0%), 2 wild male anadromous *O. mykiss* (15.4%), 2 hatchery female anadromous *O. mykiss* (15.4%), 3 male anadromous *O. mykiss* of unknown origin (23.0%), 2 wild male resident *O. mykiss* (15.4%), and 1 wild male anadromous *O.clarki* (7.8%). Of the 7 steelhead of known origin, 5 were wild (71.4%) and 2 hatchery (28.6%). Of the 10 fish with steelhead life history, 30% were wild females, 20% wild males, 20% hatchery females, and 30% undetermined origin males. Of the seven steelhead with known origin,

five were wild (71.4%) and two were hatchery (28.6%). If this is applied to the three unknown origin steelhead males it would represent two that were wild and one hatchery. Of the 10 steelhead, it was a 50/50 ratio of females/males.

In 2014 a total of 44 steelhead redds was found in the five Mid Skagit basin tributaries regularly surveyed (Table 4) with another 5 redds found in the four tributaries intermittently surveyed (Table 5). If the fish related to those 44 redds of the regularly surveyed streams in 2014 were similarly occupied as those found in the 5 active spawning participant findings, it would mean 2.6 fish per redd with a total of 114 fish. Of those 114 fish, 88 would be of steelhead life history. Of the 88 steelhead of which the actual redd construction was related, there would be 44 females and 44 males. Of the 26 unknown origin male steelhead 19 would be wild and 7 hatchery. The resulting composition would be 26 wild female steelhead, 18 hatchery female steelhead, 37 wild male steelhead, 7 hatchery male steelhead, 17 wild male resident *O. mykiss*, and 9 wild male sea-run cutthroat.

Due to the small sample size to draw from, the extension of the above breakdown to the number of redds found can only be considered a rough estimate. For instance, one of the unknown origin male steelhead sighted was an estimated 46-51 cm in length that could have equally been a resident *O. mykiss*. It could also be that the unknown origin males were either all wild or all hatchery. However, it does provide an accurate representation that the Mid Skagit tributary streams are complex spawning grounds from mid January to early June regarding wild and hatchery steelhead, their resident *O. mykiss* life history, and their interactions with sea-run cutthroat. This complexity has gone undocumented as a result of the abbreviated temporal window previously used for Puget Sound steelhead spawning surveys that has particularly excluded the ability to determine the level of feral hatchery steelhead spawning that occurs compared to wild and the life history mix that can result in hatchery/wild *O. mykiss* spawning interactions.

Considerations of How Well the Observed Active Spawners Represent the *O. mykiss* Spawning Populations

Because the active steelhead spawner observations were limited to 7 sightings (Table 8) over the five years of the 2010-14 Mid Skagit tributary surveys out of a total of 104 spawning redds found (Table 6), and 5 active sightings in 2014 (Table 8) of 44 spawning redds found (Table 3), it leads to a discussion of how well 7-11% of the spawning activity evidence represents the *O. mykiss* spawning that occurred in these two periods.

It is possible that wild adult steelhead confined to small tributary environments during spawning are particularly elusive and difficult to initially observe and even more difficult to further observe once initially sighted. As but one example, on January 19, 2011 a hatchery steelhead spawning pair was observed (and photographed) in the South Skagit Highway ditched section of Savage Creek at evening of a cloudy day. The two hatchery steelhead, a female and a male, allowed close observation despite the open roadway with my visible presence. A second male steelhead with red gills and sides immediately fled downstream to a culvert (or perhaps even beyond) before it could be determined if there was an adipose fin or not (wild or hatchery origin) and before a photo could be taken. The very different reactions of the one fish to the other two suggested the potential that the fleeing male may have been wild as a result of inherent streambred selection for caution. On return to Savage Creek in the morning of the next day, the hatchery female steelhead was still present with the redd greatly enlarged, but with no remaining evidence of the hatchery male steelhead. However, downstream a male steelhead of more vivid red gill and side coloration than either of the males sighted the previous day was briefly sighted before it fled downstream. A photograph was attempted but with results too blurred to make any determinations. Again the hatchery origin female remained in close proximity without fleeing.

Of 16 steelhead Mid Skagit tributary steelhead observed, including the previously described female observed twice in two days with differing mates (total of 17 sightings to evaluate), 67% of the wild fled when I was sighted, 33% of the wild did not, 0% of the hatchery fled, 100% of the hatchery did not, 67% of the undetermined origin fled, and 33% of the unknown origin did not (Table 15). The known wild steelhead most often fled and none of the hatchery steelhead fled. Most of the unknown origin steelhead fled suggesting more were wild than hatchery, and the unknowns that did not flee were somewhat more likely to be hatchery.

Table 15.

Stream	date	wild flee	wild remain	hatchery flee	hatchery remain	unknown flee	unknown remain
Finney	3/5/2010	1				1	
Savage	1/19/2011				2	1	
Savage	1/20/2011				1	1	
Dry	1/16/2014				1		
Dry	2/19/2014		1*			1	
Dry	3/12/2014				1		1
Finney	3/28/2014	1	1				1
Dry	5/12-2014	2					
Totals		**4 (67%)**	**2 (33%)**	**0%**	**5 (100%)**	**4 (67%)**	**2 (33%)**

* This wild female did not flee as rapidly as its unknown origin mate. Both were in a white water pocket partially shrouded by bubbles. It is possible the female did not actually see me until I moved quite close and then fled. Nevertheless, its mate fled more quickly and this one is counted as having remained.

It is known that wild steelhead selected for spawning and thereafter reared in a hatchery environment result in domestication even within the first generation (Christie et al. 2012a) and that this domestication in hatcheries also occurs in Atlantic salmon (Debesa and Hutchings 2014). The latter have a similar life history to steelhead and an increased vulnerability to predation was found (implying less caution). Domestication via hatchery rearing also occurs rapidly in other fish species such as found in Atlantic cod (Mayer et al. 2011). Not only does domestication occur in the hatchery population on release into the wild, but it is also conveyed to the supplemented wild populations they reside and interact with and with resulting reduced productivity (Reisenbichler and Rubin 1999; Reisenbichler et al. 2004). This can persist even after cessation of hatchery stocking (Araki et al. 2009). How long it takes to be selected out apparently remains little known.

The combined observations of wild and hatchery steelhead reactions to being observed were not entirely conclusive due to including six steelhead of unknown origin, but they favored the probability that wild origin steelhead are more inclined to flee when observed than hatchery steelhead. The reason for these observed differences to human proximity (or that of a large animal) of steelhead in the spawning tributaries could be a result of retained domestication from juvenile hatchery pond rearing in the case of the hatchery steelhead. If this is the case, and significant numbers of wild steelhead flee prior to being observed by the surveyor, the active steelhead spawning sightings would tend to favor hatchery over wild. However, except for Finney Creek, the streams surveyed are very small which greatly favors sighting steelhead presence. Also, due to prior histories of timber harvest, deep pools and cover provided by large woody debris are less common than was likely the historical case for the Mid Skagit tributaries surveyed. This results in fewer places for steelhead to effectively hide in these small streams.

What was conclusively evident was that by increasing the survey frequency in 2014 during the early part of the survey season that is most affected by greater precipitation and streamflows (particularly common in January

and early March), the sighting of active spawning steelhead increased from that of the previous four years. The increased survey frequency at least partly mitigated for the tendency of wild steelhead to potentially flee and evade being sighted more frequently than hatchery steelhead.

Regarding how the steelhead spawning redds found may represent the actual number of female spawners, there are still other considerations. On May 12, 2014 at Dry Creek a wild steelhead pair fled from the pool they were originally in with no redd in that location at the time (Appendix C, in Table 1; and Appendix F, in Table 2). That same day 3 prominent steelhead redds were found in the 100 m downstream of these two fish and 4 more less easily distinguished possible small steelhead redds were dispersed among white water pockets 300-400 m upstream. Of the latter, it was concluded to interpret these apparent diggings as but one extended steelhead redd. All of this spawning activity had occurred since the prior survey of Dry Creek on May 6th, and all redds were considered very fresh. Subsequently on May 13th another survey was made at Dry Creek to determine if the two wild steelhead were still present, or if there was yet another fresh redd. Although there was no finding of the two steelhead, what appeared to be yet another fresh redd was found at the location they had initially fled the previous day. All in all, this was determined to be 5 fresh redds in the same time period as the potential spawning with only two steelhead observed. It remained an unresolved question of whether one wild female may have built 5 redds over some 600-700 m of Dry Creek (of which one was actually a dispersal of 4 separate spawning pits) or if there were yet other females that had entered and spawned unobserved a day or two previous to the May 12th survey. One of the large redds downstream of where the pair was sighted had been constructed at a point where the gravel of the final digging encountered a layer of hardpan clay about 10 inches down. Was that redd subsequently abandoned with further spawning redds at other locations? The wild female sighted (and photographed) was an estimated 26-27 inches (66.0-68.6 cm) in length and appeared not to be completely spawned, if spawned at all. If a number of redds had been built with eggs deposited, a female steelhead that did so would commonly appear thin of body and noticeably egg depleted. However, some female steelhead have been examined (pers. observation) that remain quite thick of body and are not easily distinguished as having spawned. Therefore if this particular female had spawned fully, partially, or not at all could not be conclusively determined. It remains that steelhead spawning in small tributaries may include female steelhead making multiple redds as the most favorable reproductive strategy.

Wild/Hatchery Findings and Genetics Considerations

Steelhead genetics research on the Washington Coast has found significant levels of wild/hatchery hybridization with resulting declines in wild steelhead productivity despite what was thought to be isolative hatchery spawn timing earlier than for wild steelhead (Seamons et al. 2012). Forks Creek, where this research took place, is a low elevation, rain and snowmelt fed tributary of the Willapa River that is not unlike a number of similarly low elevation tributary streams of Puget Sound including the Mid Skagit basin. The genetics findings at Forks Creek are entirely consistent with the 2010-2014 spawning survey findings of the Mid Skagit basin tributaries. The results of the Forks Creek research bear quoting in light of the Mid Skagit spawn survey findings:

"We tested the efficacy of the strategy of segregation by divergent life history in a steelhead trout, Oncorhynchus mykiss, system, where hatchery fish were selected to spawn months earlier than the indigenous wild population. The proportion of wild ancestry smolts and adults declined by 10–20% over the three generations since the hatchery program began. Up to 80% of the naturally produced steelhead in any given year were hatchery/wild hybrids ... Divergent life history failed to prevent interbreeding when physical isolation was ineffective, an inadequacy that is likely to prevail in many other situations."

From the cumulative findings of the active steelhead spawning redds observed on the Mid Skagit tributaries from 2010 to 2014 (Table 16): of 16 total steelhead observed, 6 were wild, 4 hatchery, and 6 of unknown origin.

Table 16. Life history, sex, and origin of live *O. mykiss* observed on redds occupied by female steelhead by tributary in the cumulative surveys of the Mid Skagit basin in 2010-2014 and in 2014 alone

2010-11 data used
2014 data used
2010-14 combined data used

Tributary	Date	Wild sthd ♀	Wild sthd ♂	Hat sthd ♀	Hat sthd ♂	? sthd ♂	**Wild resident *O. mykiss* ♂**
Finney Ck	3/4/2010	1				1	
Savage Ck	1/19/2011			1	1	2	
Dry Ck	1/16/2014			1			1
Dry Ck	2/19/2014	1				1	
Dry Ck	3/12/2014			1		1	1
Finney Ck	3/28/2014	1	1			1	
Dry Ck	5/12/2014	1	1				
2014 Total	**known origin sthd only** **known sthd with resident**	**5 wild = 71%** **7 wild = 78%**		**2 hatchery = 29%** **2 hatchery = 22%**		**3** **3**	**2** **2 res wild**
2010-14 Total	**known origin sthd only** **known sthd with resident**	**6 wild = 60%** **8 wild = 67%**		**4 hatchery = 40%** **4 hatchery = 33%**		**6** **6**	**2** **2 res wild**

Those of known origin were 60% wild and 40% hatchery. If resident males are included it was 67% wild and 33% hatchery as the *O. mykiss* population spawning mix. From the active spawning evidence of 2014 alone the adult steelhead spawning mix was 71% wild to 29% hatchery. If the resident males are included it was 78%

Table 17. Steelhead/Rainbow by Wild, Hatchery, or Unknown Origin of Spawning Mix Prior to March 15th and After at Five Mid Skagit Tributaries in 2010-14 and 2014 alone.

in 2014 with resident O. mykiss included
in 2014 without resident O. mykiss included
in 2010-14 with resident O. mykiss included
in 2010-14 without resident O. mykiss included

	Wild	**Hatchery**	**?**	**% Wild**	**% Hatchery**	**% ?**	**% Wild without ?**	**% Hatchery without ?**
Prior March 15th (2014)	3	2	2	42.86%	28.57%	28.57%	60%	40%
After March 15th (2014)	4	0	1	80%	0%	20%	100%	0%
Prior March 15th (2014)	1	2	2	20%	40%	40%	33%	67%
After March 15th (2014)	4	0	1	80%	0%	20%	100%	0%
Prior March 15th (2010-14)	4	4	5	30.75%	30.75%	38.50%	50%	50%
After March 15th (2010-14)	4	0	1	80%	0%	20%	100%	0%
Prior March 15th (2010-14)	2	4	5	18.18%	36.36%	45.45%	33%	67%
After March 15th (2010-14)	4	0	1	80%	0%	20%	100%	0%

wild and 22% hatchery as the *O. mykiss* spawning population mix. The resulting range was from 60%-78% wild *O. mykiss* and 22%-40% hatchery at the five Mid Skagit tributaries regularly surveyed over the five year period of 2010-14 based on the active spawning evidence.

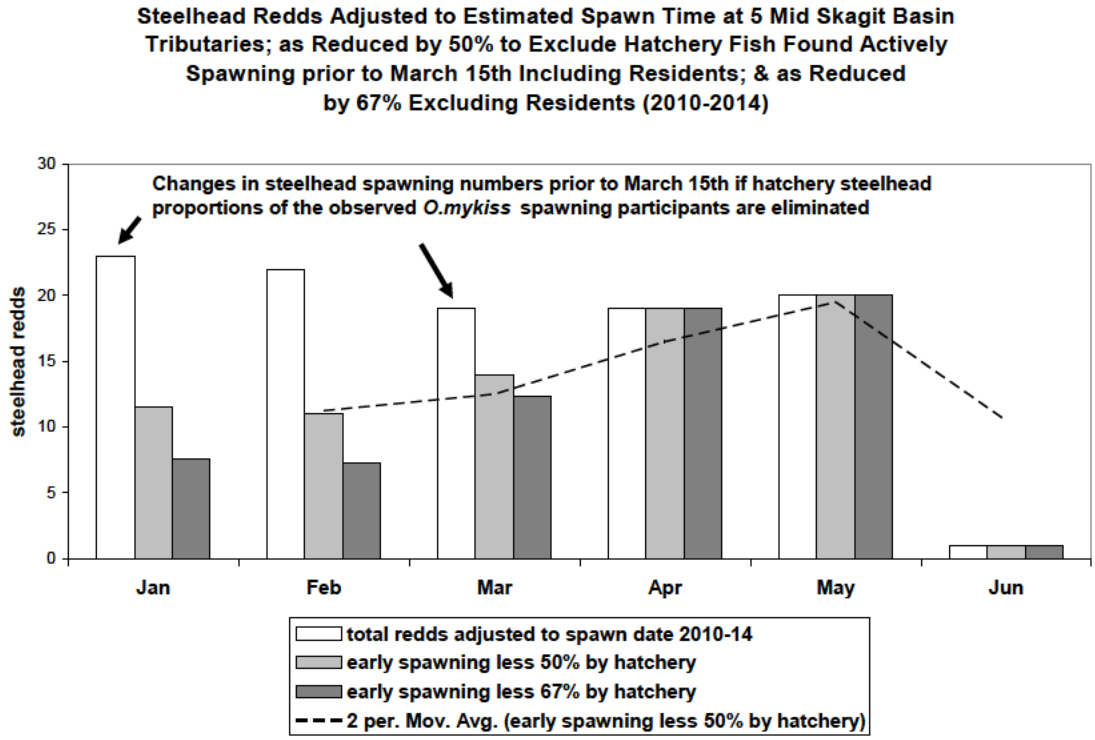
The observed active *O. mykiss* spawning at the five Mid Skagit tributaries that occurred prior to March 15th and after March 15th in 2014 (Table 17) indicates that if the resident life history is included in the spawning mix the known origin participants were 60% wild and 40% hatchery prior to March 15th, and 100% wild and 0% hatchery after March 15th. If the resident life history is excluded it was 33% wild and 67% hatchery prior to March 15th, and still 100% wild and 0% hatchery after March 15th. Over the full five year period of 2010-14 if the resident life history is included in the spawning mix the known origin participants were 50% wild and 50% hatchery prior to March 15th, and 100% wild and 0% hatchery after March 15th. If the resident life history is excluded it was 33% wild and 67% hatchery prior to March 15th, and still 100% wild and 0% hatchery after March 15th. The range of mixes considered prior to March 15th was 33%-60% wild and 40%-67% hatchery. It remains that the spawning participants of unknown origin ranged from 20%-45% of the total spawning mixes and which could alter these outcomes. However, there was little reason to believe that the steelhead of unknown origin were a significantly different mix of wild and hatchery. Judgment calls could have been made in three instances among the six unknowns, one leaning toward hatchery and two leaning toward wild, but rather than try to internally debate it further in each instance these fish were classified as unknowns. In the case of the remaining three unknowns they were simply that.

The percentage of steelhead redds found on or prior to March 15th represent the time period when wild/hatchery spawning interactions between Chambers Creek origin hatchery steelhead and wild steelhead would be more anticipated to occur than after March 15th as a result of more than 50 years of Chambers Creek steelhead selection for early spawning (Crawford 1979). Active hatchery steelhead spawning observations were indeed found wholly within the earlier time period. However, it remains that hatchery steelhead kelts were sampled in the Skagit basin throughout the month of March as well as April between 2008 and 2012 as part of a larger steelhead study (Pflug et al. 2013). Six males of unknown origin were found among the spawning mix in the 2010-14 Mid Skagit tributary surveys of which one was after March 15th and which was of a smaller size that is common for Chambers Creek origin hatchery steelhead. The limitation in active steelhead sightings to draw from in the Mid Skagit tributary surveys may well have otherwise missed documenting hatchery steelhead spawning presence from mid March through April.

If the hatchery percentages of the observed spawning *O. mykiss* spawning mixes are eliminated from the early January to March 15th spawning period, the spawning time that represents that of wild steelhead can be better identified as found in the Mid Skagit basin tributaries over the past five years (Figure 35). The range of hatchery spawning as observed among the active spawning participants prior to March 15th was 50%-67% depending on whether the wild male resident *O. mykiss* were included as part of the spawning population or not (as they should be but which often remain excluded from consideration). This significantly alters the pattern of the monthly steelhead spawning from that which did not take the hatchery component into account. The graphed data then come to better reflect a curve that is top heavy at the May end (the trendline represents the 2% moving average for 50% hatchery reduction level). Although it is tempting to conclude that this is the truer wild steelhead spawning pattern at the Mid Skagit basin tributaries, it does not take into account the probable necessities for a spawning curve that is top heavy toward the earlier time period, rather than the later, for the three tributary streams of the five regularly surveyed that have intermittent flows. Conversely, a pattern that is even more skewed toward the latter period may well be the actual spawning curve that better fits those streams with perennial flows. What Figure 34 can't further depict is the amount of early (or later) steelhead spawning

that includes wild/hatchery hybrid participants and what the overall drain on early wild steelhead spawning productivity has been due to wild/hatchery interactions at all combined levels. It also does not depict what the effects of decades of focused harvest on early return wild steelhead has been as by-catch that targets the hatchery returns at what have been 80%-95% harvest rates set by WDFW and Western Washington Treaty

Figure 35.



Tribes (SASSI 1994; McHenry et al. 1996). It is particularly likely that wild steelhead productivity in those tributary streams of the Skagit River basin that have portions of their mainstems and/or side channels used for spawning that go intermittent have been particularly affected by interactions with hatchery steelhead that apparently target these same spawning areas. It is necessary for early spawning to occur if these streams are to be fully productive for wild steelhead. This will loom even larger in importance given future considerations related to climate change.

The steelhead spawning in Mid Skagit tributaries includes both wild and hatchery steelhead that have overlapping periods of spawning with significant opportunity for hybridization to occur, as would be anticipated from the Forks Creek wild/hatchery steelhead genetic findings (Seamons et al. 2012). The finding of wild resident male *O. mykiss* as part of the spawning mix indicates that they further increase the opportunity for the overall wild and hatchery *O. mykiss* populations to hybridize. The mature male parr life history form of *O. mykiss* was considered to contribute 39% to overall wild steelhead production at Snow Creek of Puget Sound (Seamons et al. 2004). Potential mature male parr contributors to the steelhead spawning mix are fish too small to be have been noticed during the Mid Skagit basin tributary surveys, but the percentages indicated in the literature suggest their probable presence. At Hood River the importance of wild male resident contribution to the steelhead population was described by Christie et al. 2011:

Page 1263: *"... while 20% of steelhead genes come from wild residents. A further 23% of anadromous steelhead genes come from matings between two resident parents. If these matings mirror the proportion of matings between residualized hatchery fish and anadromous partners, then closer to 40% of all steelhead genes come from wild trout each generation."*

Further Genetic Considerations

Through direct observations of active steelhead spawning during the Mid Skagit basin tributary surveys it has been clearly evident that significant spawning interactions are occurring between wild and hatchery *O. mykiss*. The observed spawning interactions also indicate that gene flow between the wild and hatchery populations of steelhead and the inclusive resident life history of *O. mykiss* are likely occurring at similar levels to the identified spawning participants. Over the full steelhead spawning period the spawning mix was 71% wild to 29% hatchery in 2014, and 60% wild to 40% hatchery in the longer 2010-2014 period. It was 78% wild and 22% hatchery in the case of a mixed steelhead/*O. mykiss* spawning population in 2014, and 67% wild and 33% hatchery in the cumulative 2010-2014 period. In 2008, hatchery steelhead smolt plant numbers were significantly reduced by over 50% (Pflug et al. 2013) with reduced numbers of returning adult hatchery steelhead potentially occurring from 2010 onward. Therefore, the 2010-2014 Mid Skagit basin tributary surveys did not capture what may have been an even higher former level of hatchery steelhead on these spawning grounds. The wild/hatchery spawning interactions observed were all between mid January and mid March. Therefore the earlier return component of the wild steelhead population would be anticipated to have been affected by the greatest gene flow from hatchery steelhead with resulting productivity loss as indicated at Forks Creek on the southwest Washington Coast by Seamons et al. (2011). The only real question about gene flow is at what level it survives to be measured by the present analytical tools and collection methodologies used, and at what hidden level this may occur in eggs, alevins, and very early fry most recently emerged that remains little known. Furthermore, how well are the predominant early spawning areas being sampled from which to best document these wild/hatchery interactions that apparently are most commonly occurring in tributary streams that have some level of intermittency?

Regarding whatever future steelhead genetic work may occur in the Skagit basin regarding a determination of wild/hatchery hybridization, or that of feral hatchery/hatchery spawning, the spawning period when this is most likely to occur as found in the Mid Skagit tributary spawning surveys is from January through March with anticipated fry emergence that could be from late April to mid June. Due to the greatly reduced survival of hatchery/hatchery feral spawning found in numerous steelhead studies, and the reduced survival of wild/hatchery hybrids, it would be anticipated that greater loss of these rearing *O. mykiss* of purely hatchery or wild/hatchery origin would especially occur during their earliest life history stages on exposure to natural selection. The least fit would be anticipated to be most abundant shortly after emergence (or before emergence) with increasing diminishment throughout the rearing period with the more fit being the latter survivors that are much reduced in numbers. Sampling juvenile *O. mykiss* for genetic determinations in the tributaries of the Mid Skagit basin should, therefore, occur as close to emergence time as possible in order to most effectively detect whatever hatchery heritage is present. This time period, depending on annual climate variations, should be from late April to mid June. Any later and it would be anticipated that the hatchery genetic signal (no matter what genetic analytical method is used) in a tributary population of steelhead that may have occurred during natural spawning would have been diminished as a result of natural selection that would favor wild heritage survival and with any hatchery heritage genetic signal increasingly diminishing over the extent of rearing time.

In the case of the Skagit basin, if Chambers Creek origin hatchery steelhead continue to be curtailed from 2014 onward for at least 12 years, as a recent lawsuit settlement agreement has indicated, the last two-salt life history return of this hatchery stock would be the spawning year of 2015 from the 2013 smolt plants, and continuing into the spawning year of 2016 if some level of three-salt hatchery returns occurs. However, it remains that some level of hatchery introgression into the Mid Skagit tributary *O. mykiss* populations may continue with a genetic signal thereafter for an unknown period through what has been termed the "carry over effect" (Araki et al. 2009). It also remains to be determined if some other hatchery steelhead program may occur from which these considerations for monitoring the Mid Skagit tributary steelhead populations related to potential hatchery effects may remain valid.

The baseline of information on steelhead/*O. mykiss* spawning that has now been collected at Mid Skagit tributaries throughout the breadth of their spawning period can provide a basis to guide juvenile collections for genetic analysis, as well as that of providing a guide for when to initiate future steelhead spawning surveys in a way that can capture the full breadth of spawning by *O. mykiss* that occurs.

Evidence of Skagit Basin Tributary Steelhead Spawning and Genetic Diversity about 35 Years Ago

Of background interest, a study of the genetic structure of wild steelhead throughout the Skagit basin was initiated in 1979 through electrophoretic analysis of tissue proteins from age 0+ juveniles taken at 57 sample sites (Phillips et al. 1981a). Intended to be a three year study, it was abandoned after the first year with no follow up. While no significant differences were found between Skagit and Sauk River steelhead, the Cascade River steelhead were found significantly different. However, the greatest level of gene frequency differences with the greatest variability was found between individual tributary creek samples of the Skagit basin and between the general geographic areas these tributaries are within. Significant portions of the only known remaining copy of this study are missing leaving gaps in what can be understood, but the primary finding of this within-basin genetic differentiation was acknowledged by Phelps et al. (1994). Finney and O'Toole creeks of the Mid Skagit basin were among the tributary streams sampled and genetically evaluated in what remains of that 1981 report. The Phillips et al. (1981a) steelhead genetic study of the Skagit basin was in the same period of time when the tributary creeks of the Skagit basin were supporting 65-80% of all the steelhead spawning (Phillips et al. 1981b) as found by spawning surveys conducted in the Skagit basin from 1978 to 1981. Despite their relatively small size, Skagit tributary creeks have a large presence in its steelhead history. These historical reports on Skagit steelhead tributary findings provide an historical baseline for further comparisons today and as an aid to recovery planning.

Reasons for Steelhead Spawning Time Differences

Water temperature and a combination of precipitation and streamflow levels have been identified as contributive factors controlling steelhead spawning time (Briggs 1953; Shapovalov and Taft 1954; Crawford et al. 1979; Cederholm 1984). Earliest spawning migrations typically occur for salmon and steelhead destined for uppermost watershed locations at both the larger watershed scale and that of smaller tributaries, and differences in both streamflow and temperatures further result in differing general entry times for spawning (Briggs 1953). Streamflow patterns also predictably determine spawning time differences of steelhead in tributaries as compared to mainstem locations which Oregon spawning surveys are planned around (Susac and Jacobs 1999). Intermittent streams have further controls on time of spawning related to successful *O. mykiss* emergence and non-lethal rearing opportunities that fry-to-parr survival ultimately depend on in migrations from drying natal streams to perennial ones for rearing (Everest 1973; Erman and Hawthorne 1976; Boughton et al. 2009). All of

these factors are relevant to steelhead/*O. mykiss* spawning found in Mid Skagit basin tributaries. It is informative to examine the comparative literature regarding steelhead/*O. mykiss* spawning elsewhere and how it may more broadly relate to the Skagit basin in the past and into the future.

Temperature and Precipitation/Streamflow

Cederholm (1984) indicated that a combination of water temperatures and streamflows were the likely drivers of steelhead spawning time differences he found in differing years at the Clearwater River and its tributaries of the Queets basin on the Northwest Washington coast. In seven years of spawning surveys he found a 39 day difference in annual peak spawning dates of wild steelhead prior to hatchery introductions into the Queets basin. The primary correlation in this shifting spawning time peak was thought to be water temperature differences with the earliest peak spawning being in the year when water temperature reached 7 C on or before March 16th but which did not occur in the latest year until April 10th. The 7 C water temperature was the midpoint recommended water temperature for steelhead spawning as determined by Reiser and Bjornn (1979). The 25 day difference they documented in achieving the 7 C water temperature was considered by Cederholm to be relatively comparable to the 39 day differences found in peak steelhead spawning at the Clearwater River and its tributaries surveyed. By contrast, entry time of steelhead did not alter as determined by the lower Queets River tribal steelhead fishery. Therefore the differences in peak spawning dates were likely determined by annually differing environmental factors that occurred after initial Queets River entry, especially water temperature and at a more general long-term scale by streamflows. He also found that tributary spawning time varied widely between streams and on the whole tributary spawning peaked earlier than in the mainstem. Tributary spawning began in January some years and as late as June, virtually identical to that found in the Mid Skagit basin tributaries. Cederholm also indicated that spring steelhead spawning is a disadvantage for some juvenile steelhead due to emerging from the gravel in mid- to late summer (June to August). As a result, many later spawning steelhead are of small size going into their first winter and must spend two or more winters in freshwater with related added mortality prior to smolting. Given this consideration, early spawning as found in Savage, Dry, Finney, and some years Mill Creek in the Mid Skagit basin could result in greater juvenile growth going into their first winter and subsequent higher overall survival; late spawning could result in reduced juvenile growth going into the first winter and reduced survival. This would, however, be balanced by high streamflow peaks in the earlier spawning period and more stable streamflows in the later spawning period that may otherwise select for survival depending on the year and individual stream.

At the Kalama River there were two back-to-back years of significantly different temperature and flow conditions that affected steelhead spawning (Crawford et al. 1979). The 1976-77 winter was one of drought and cold average temperatures while 1977-78 was a winter with a 100-year flood and remained warm and rainy throughout. Steelhead began spawning 37 days earlier in 1977-78 with a resulting two month earlier spawning peak (mid January opposed to mid March) than in 1976-77.

In the detailed studies at Waddell Creek on the California Coast, steelhead waited off the mouth of the creek for spawning migrations upstream until the opening of blocking sand bars occurred with the first fall storms (Shapovalov and Taft 1954). The initial entry of steelhead with earliest storms was comparatively small to that of subsequent entries with each storm that followed until the end of the spawning entry season. The complete breadth of entry as trapped at the Waddell Creek weir was from October 28th through July 21st, but 96 percent of all the steelhead were counted during the 22 weeks from December 3rd to May 5th. Of all fish trapped during the nine years of study (1934-1942), 39 percent of the fish were taken from March 1st onward (61 percent prior to that). Steelhead upstream migration for spawning was dependent on seasonal variations in weather and water

conditions with a strong relationship to streamflow. Migration typically ceased at peak flood flows, but could occur on both rising and falling levels. Climatic conditions were thought to be a factor as was water turbidity and sexual ripeness. It was found that there were two peaks of upstream movement, one in the week ending January 6th and the other for the week ending March 17th.

In the case of the Mid Skagit basin tributaries, both temperature and streamflow appear to have a relationship to spawning entry and time similar to that described at both Waddell Creek and at tributaries of the Clearwater River.

Precipitation/Streamflow Relationships to Spawning Entry

Outside the Mid Skagit basin, the Waddell Creek example of steelhead spawning migrations dependent on storm events and high streamflows (Shapovalov and Taft 1954) is comparable to steelhead spawning entry limitations at the Mid Skagit tributaries. Of the five tributary creeks regularly surveyed, three have gravel deposition bars that have built up at their mouths (Finney, Dry, and Savage creeks) that can restrict anadromous fish entry to periods of higher streamflow in the tributary itself, and/or higher streamflows in the Skagit River or the mainstem the tributary enters. In the case of Dry Creek, its deposition bar is at entry to Finney Creek (Photo 4), but Savage and Finney Creek deposition bars are at entry to the Mid Skagit River (Savage Creek entry Photo 16). This is not unlike the sandbars that must be breached by periodic Pacific storms for entry to Waddell Creek (California Coast) throughout the spawning return period. At two of these Mid Skagit tributaries in 2014, Dry and Savage creeks, 50-100% of steelhead redds found were prior to March 15th (Figure 2). In the cumulative period of 2010-2014 it was 65-94% of the steelhead redds found prior to that date in the same two tributaries (Figure 4). Like at Waddell Creek, steelhead spawning entry prior to early to mid March was dominant at two creeks where spawning entry is controlled by flow, in this case gravel bars at their mouths rather than sand bars.

As an observed example of streamflow effects related to spawning entry (Photo 16): on the evening of January 29, 2014, after lack of rainfall since January 16th, there was 0.85 inch rainfall measured in my gage near the mouth of Savage Creek near Birdsview (Appendix F, Table 2). At the Concrete gage it was 0.18 inch rainfall on January 29th, likely occurring in very early morning, and 0.40 inch on January 30th likely from the previous day with a cumulative total of 0.58 inch probably occurring on January 29th if the Concrete gage was emptied at 8:00-9:00 am each day. As is the common pattern, there was less rainfall at Concrete than at my Birdsview area gage. Although Savage Creek did not appreciably rise in flow, a steelhead (or less likely by that date a coho) twice attempted entry over the shallow bar from the Skagit River. Its splashing was sighted from 100 m upstream. Despite the vigorous efforts it failed to enter and dropped back into the main river, potentially entering later with subsequent continued precipitation and rise in flow. Rain continued for another two days. On spawning surveys of Dry and Finney creeks on February 2nd two inactive redds were found that were likely made after successful entry with the rise in flows due to the initiation of rainfall on January 29th. However, no corresponding redd was found at Savage Creek on January 30th or on February 16th and 18th in the creek sections surveyed. On February 20th two inactive redds were found at Savage Creek, but they were estimated as built within the week not 2-3 weeks previous. This was likely related to 4.4 inches of rainfall measured at my Birdsview gage between February 15th and 19th and 5.27 inches as measured at the Concrete gage between February 10th and 20th rather than the prior rainfall in late January. Steelhead angling remained open on the Skagit River through January 31st with hatchery steelhead legal to harvest. Potentially it was a hatchery steelhead sighted attempting entry to Savage on January 29th that was subsequently harvested, or perhaps with denial of entry on that date the steelhead (or coho) spawned in the mainstem Skagit or nearby Grandy Creek

directly across the Skagit River. Alternatively it could have entered and spawned in Savage Creek in one of the anadromous sections of the creek that was not surveyed on January 30th and subsequent surveys missed it due to significant rainfall occurring during the February 10-20th time period that erased evidence of any redd. It remains that Photo 16 well depicts the necessity for sufficient streamflows required at some Mid Skagit tributaries for steelhead spawning entry to occur.

Photo 16: Savage Creek Deposition Bar at Entry to the Mid Skagit River

Although the Finney Creek deposition bar at entry to the Skagit River is an obstacle at lower October through May flows of typical anadromous fish entry, it more commonly remains navigable for spawning entry due to its larger size and greater overall flow. Both early and late steelhead spawning occur at Finney Creek with 10-38% (average 35%) prior to March 15th (Figures 4, 5, and 6).

From January to June there is generally declining precipitation except for a precipitation spike in March as the average trend in the 2010-2014 Mid Skagit tributary survey period (Figures 21 and 22; and Appendix A, Tables 1 and 2). The steelhead entry and spawning at Savage and Dry creeks are likely driven in part by greater precipitation prior to April. Although February precipitation is about the same as April, January's precipitation can include considerable snow which sustains February flows as it begins to melt in these smaller tributaries of relatively short length dominated by lower rather than higher elevations (Figure 17). Passage over obstructing deposition bars at their stream mouths is likely more favorable for steelhead prior to April if precipitation amount is a proxy for streamflow at these two tributaries. Because of so little of their drainage being at higher elevation they are rain and snowmelt driven with relatively immediate response to precipitation except during generally short periods of snowfall of 1-2 weeks. Although the streamflow data from the North Fork Stillaguamish River may well be a surrogate for the streamflow pattern at Finney Creek (Figures 26) that is more independent of precipitation patterns from March through May (Figure 28), this is less likely at Savage and Dry creeks. Finney Creek's more extensive length at higher elevations prior to meeting the Skagit Valley

floor likely results in more delay of snowmelt that has accumulated (Table 18). Snow accumulation from 760-1070 m is considered transitory with rain-on-snow storms from October to February resulting in most of the peak flows, while the uppermost 479 m to its 1,549 m source at Finney Peak is apparently longer term snowpack (Nichols and Ketcheson 2013). Although other Mid Skagit basin tributaries drain elevations as high as the actual stream channel source of Finney Creek (as determined from Google Earth measures), their elevations that are above 500 m (1,640 ft) are comparatively short stream lengths, while upper mainstem Finney has 6.0 mi (9.66 km) that are above 500 m, plus another 4.48 mi (7.2 km) at two of its larger headwater tributaries. The two Mid Skagit tributaries regularly surveyed with the least lineal lengths of their drainages above 500 m are Dry and Savage creeks, also the streams with earliest spawning and greatest mainstem lengths that go intermittent the earliest.

Table 18. Stream Lineal Lengths, Drainage Areas (if available), and Source/Mouth Elevations for the Five Mid Skagit Basin Tributaries Regularly Surveyed and Rarely Surveyed *****

Rarely surveyed
Least stream lengths above 500 m elevation of Mid Skagit tributaries regularly surveyed

Stream	Length miles miles (km)	Area mi2 (km2)	Source elevation feet (m)	Mouth elevation feet (m)	Stream length above 500 m in miles (km)	Reference
Savage	2 1 (3.4 km) 3.86 (6.2 km)	....	.... 2,715 (828 m)	.... 113 (34.4 m)	0.35 (0.56 km)	Williams et al. 1975 Google Earth measures
Mill	4.6 (7.4 km) 4.7 (7.6 km)	....	.... 3,300 (1,006 m)	.... 112 (34.1 m)	.... 2.58 (4.15 km)	Williams et al. 1975 Google Earth measures
O'Toole	4.0 (6.4 km) 3 5 or 5.6 (5.6 or 9.0 km)	....	.... 2,500 or 3,800 (762 or 1,158 m)	.... 111 (33.8 m)	.... 2.0 or 3.98 (3.2 or 6.4 km)	Williams et al. 1975 Google Earth mearsues
Finney	23.98 (38.6 km) 23.8 (38.3 km)	54 (140 km2)	5,082 (1,549 m) 3,560 (1,085 m)	134.5 (41 m) 125 (38.1 m)	.... 6.0 (9.65 km)	Nichols & Ketcheson 2013 Google Earth measures
Dry	2 1 (3.4 km) 2.4 (3.9 km)	....	.... (604 or 790 m)	.... 167 (50.9 m)	.... 0.15 or 0.43 (0.24 or 0.69 km)	Williams et al. 1975 Google Earth measures
Cumberland	5.4 (8.7 km) 4 1 or 5.0 (6.6 or 8.0 km)	....	.... 2,730 or 2,900 (832 or 884 m)	.... 91 (27.7 m)	....	Williams et al. 1975 Google Earth measures
Grandy	7.6 (12.23 km) .... 7 2 or 8.4 (11.6 or 13.5 km)	.... 19.7 (51 km2)	.... 1,000 or 4,000 (305 or 1,219 m)	.... 113 (34.4 m)	....	Williams et al. 1975 Ames & Bucknell 1981 Google Earth measures
Hatchery	3.4 (5.5 km) 3 3 (5.3 km)	....	.... 3,000 (914 m)	.... 236 (71.9 m)	....	Williams et al. 1975 Google Earth measures
Quartz	3 5 (5.6 km) 3 1 (5.0 km)	....	.... 3,182 (970 m)	.... 234 (71.3 m)	....	Williams et al. 1975 Googel Earth measures

***** Google Earth measures determined were to stream channel ends that could be followed, and source elevations were similarly so and not to the height of the surrounding mountains they may drain.

In the coastal Oregon steelhead spawning surveys it was found that steelhead spawning in tributaries coincided with freshet conditions and that as a result the surveys focused on mainstem rivers during low flow periods and later in the spawning season (Susac and Jacobs 1999). Precipitation in the Mid Skagit basin is greater from January through March than thereafter (Appendix A, Tables 1 and 2) and it would be anticipated that steelhead spawning in the tributary creeks are sometimes driven by this greater precipitation period, particularly in those streams where entry may be otherwise deterred by gravel deposition at their mouths as previously described. The two Mid Skagit tributaries regularly surveyed that have deeper channels at their mouths without a deposition bar to overcome for anadromous fish entry from October through May are O'Toole and Mill creeks.

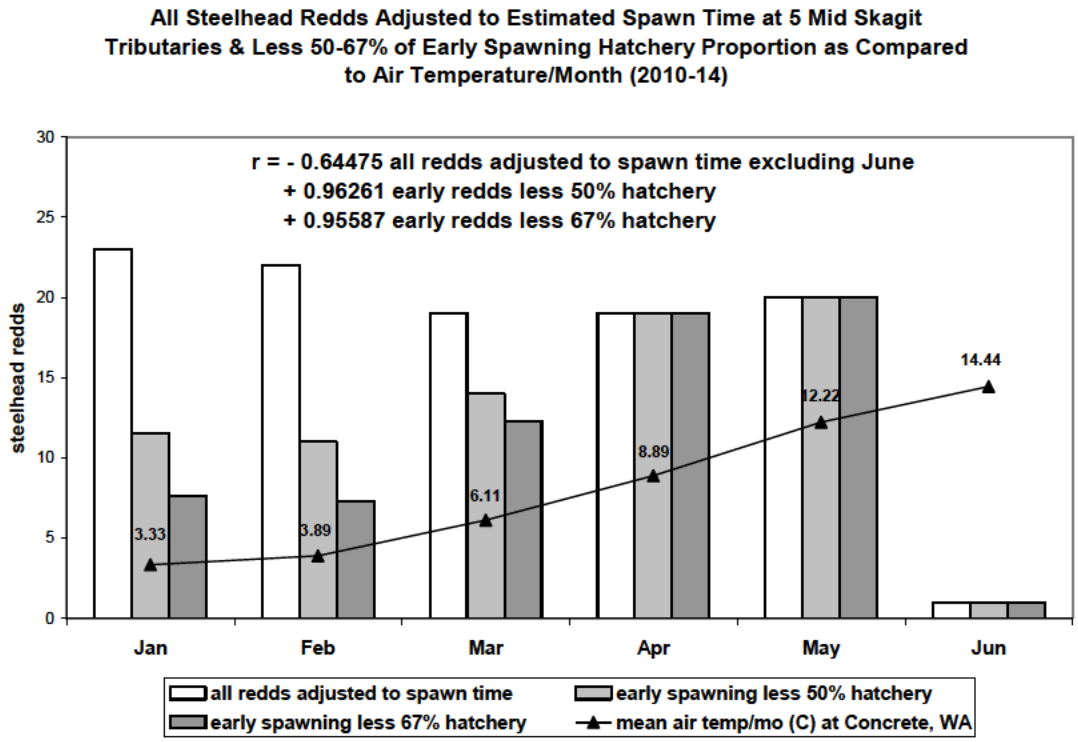
O'Toole Creek steelhead spawning is mostly later in the season (78%) and Mill Creek has both early (59%) and later (41%) spawning by steelhead (Figure 4).

A pattern of earlier entry for steelhead and salmon destined for upper watershed spawning destinations has also long been noted to occur (Briggs 1953), and that this can even occur at the smaller tributary scale as found at Prairie Creek on the California coast. At Prairie Creek earliest spawning more densely occurred in the upper watershed portion and progressively shifted down the watershed through the steelhead spawning period. At the larger Skagit basin level, one would anticipate that uppermost watershed areas would particularly depend on earlier entry time to reach those more distant spawning destination locations. However, this may not necessarily mean earlier spawning than elsewhere in the basin. It was also determined that while both flows and temperatures determined spawning migrations that it was difficult to isolate one from the other:

Page 13: *"In the California north coastal region the stream rises in the winter time almost always seem to be accompanied by sharp temperature increases ... This fact makes it difficult to separate the effects of these two environmental factors."*

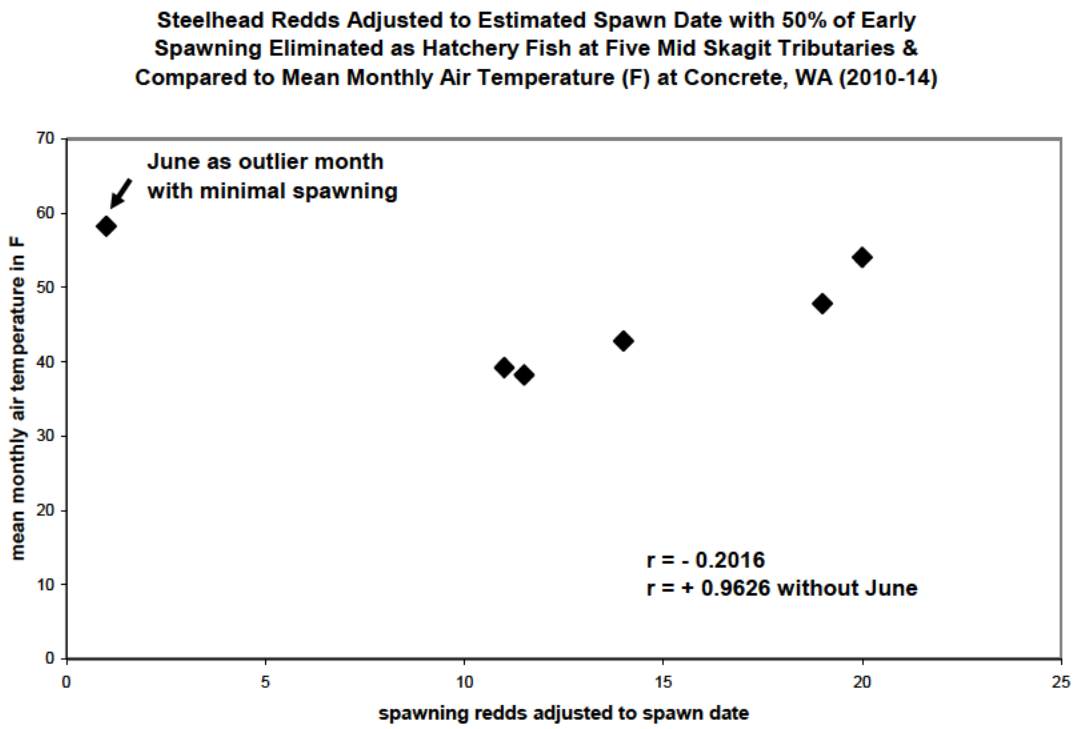
Coinciding environmental variables may also have been a reason for the inability to find significant correlations between flows, precipitation, and temperatures in the Mid Skagit basin tributaries. Furthermore, the hatchery steelhead spawning time may have a somewhat different driver (narrower period of primary spawning time for instance that is determined through hatchery selection) that predominates compared to the generally broader distribution of spawning time for wild steelhead as depicted when hatchery steelhead were eliminated from the spawning mixes in Figure 35. The data that included hatchery steelhead from which correlations were determined between spawning time and air temperature, precipitation, and streamflow may have been one factor

Figure 36.



that confounded the ability to find significant correlations. However, on eliminating 50-67% of the early spawning between January and March 15th to represent the actual wild spawning mix (including residents along with steelhead) found at the Mid Skagit tributaries by eliminating the proportion found to be hatchery steelhead on the active redds, it remained that streamflow and precipitation did not have any more significant correlations

Figure 37.



than previously done. Air temperature, as a surrogate for stream temperatures was another matter and was found to have a much stronger comparative pattern with wild steelhead spawning (Figure 36) and resulting correlation (Figure 37) than previously found when the potential proportion of hatchery steelhead in the overall population was not excluded (Figures 15, and 16). A highly significant Pearson's correlation "r" of + 0.9626 was found (at 50% reduction of early spawning by hatchery fish) if June is eliminated as the outlier month when minimal steelhead spawning occurs in the Mid Skagit tributaries regularly surveyed. June may result in air/water temperatures at low elevation streams commonly beyond the maximums for steelhead indicated by Bell (1973) and Bovee (1978) of 9.4-13 C (48.9-55.4 F).

C. Intermittent and Perennial Streamflows

Everest (1973) found that the high summer steelhead productivity in the Rogue River basin was dependent on intensive spawning use of small tributaries with watershed basin areas of less than 25 square miles and winter streamflows of less than 50 cfs. Most of these streams became intermittent in summer, as early as mid June, and yet supported large steelhead spawning populations in winter while going completely dry in summer. As a result, most fry had to migrate from these streams to larger tributaries or the mainstem soon after emergence. As but one example, Kane Creek was intensively studied and supported more than 2,000 spawning adults despite being dry from August through October. Peak spawning in the 1979-71 water year occurred from late

January through mid February shortly after a peak maximum flow event on January 18, 1971. Peak fry outmigration occurred in May.

It is apparent from the Rogue River example that intermittent tributary streams are not only used by steelhead for spawning, but that they can support very large numbers of spawning steelhead per size of watershed. In the case of the Mid Skagit basin tributaries, the one stream that is of smallest estimated winter streamflow, and with a greater percent of its anadromous length going dry every summer (about 50%), is Dry Creek. Yet, 14 steelhead redds per kilometer were found at Dry Creek in 2014, which was about 2-10 times greater density of steelhead redds found than at any of the other four tributaries (Table 4). Emergence of *O. mykiss* fry was found in Dry Creek by mid to latter May, with probable emergence even earlier. This was sufficiently early to provide downstream migration to Finney Creek, and/or the Skagit River prior to its lower portion going subsurface likely several days prior to its being photographed on June 27th (Photo 5). As at the Rogue tributaries, steelhead spawning began in latter January (hatchery female steelhead and wild resident male) and February (wild female steelhead, undetermined male steelhead, and sea-run cutthroat male) in 2014. In 1978-1981 it was found that 65-80% of Skagit basin steelhead spawning occurred in the tributary creeks rather than the mainstems (Phillips et al. 1981b). However, it was thought that while the majority of the spawning occurred in the tributaries, most of the rearing to result in the adult returns must occur in the mainstems which even at that time were thought to be below carrying capacity and could accommodate still more. Although intermittency was not considered on the Skagit 35 years ago, the movement of juveniles from the tributaries to the mainstems was otherwise of the same pattern as on the Rogue.

Of the five Mid Skagit basin tributaries regularly surveyed in 2014, only O'Toole Creek remained completely perennial throughout the summer period (Table 12; and Photo 12). Significant portions of all the others went intermittent at varied times from May 30th to August 1st. In the case of Finney Creek, the largest of the streams surveyed, its mainstem remained perennial but numerous significant side channels where *O. mykiss* spawn and/or rear began to go intermittent by May 30th. There were known losses of large numbers of mixed salmonid fry and some parr that included *O. mykiss* photographed in late May as these side channels approached complete dewatering (Photo 14). The lowermost tributary of Finney Creek, Dry Creek, went intermittent in its lower 70 m by June 24-27 and progressed upstream as previously described leaving only the upper 400-500 m wetted from mid July onward. Nevertheless, it supported the highest level of steelhead spawning found at 14 redds/km, nearly double the next highest steelhead spawning in any of the other four tributaries regularly surveyed (Table 4). Dry Creek also has the most confined and stable channel of the five streams regularly surveyed, and while its spawning gravel has considerable fine sediment, it is much less so than the gravel of Finney Creek from visual estimates.

In the case of lower Savage and Mill creeks, both have had significant depositions of gravel related to landslides and/or bank erosion further upstream. These gravel depositions are likely related to their logging land use histories and aggravated by major flood events in the Skagit basin that have increased from eight of over 90,000 cfs in the 30 year period of 1948-1977 to fourteen in the 30 year period of 1978-2007, nearly double the flood event frequency of over 90,000 cfs from the earlier period (Appendix D). Weather pattern shifts related to climate change are likely contributing to this and shifts toward increasing changes in flow patterns are predicted to particularly occur in the northern Pacific Northwest (Wade et al. 2013). Despite the present conditions, that may or may not have been the case regarding the prior hydrology and geomorphology histories of these two tributaries, they are annually used for spawning and seasonal rearing by steelhead and other salmonids. They were even more prevalently used by steelhead about 35 years ago (Table 19; and Phillips et al. 1981b). At the time of the 1978-1981 spawning surveys there was no data provided if the streams included at the time were a

mix of perennial and intermittent or not. Presumably portions of the lengths of some were intermittent, as is the case today, but that can't be determined from the information provided. Of the 26 Skagit River tributary creeks surveyed at that time, Finney, Mill, and O'Toole were included for some or all years and steelhead spawning use in the differing eras can be compared (Table 19). Steelhead spawning use has significantly declined in these three Mid Skagit basin tributary creeks since that earlier period based on the 2014 survey findings and is now 35-78% of that in the past. Yet, the wild steelhead preliminary escapement estimate for 2014 is higher than any of the years in the 1978-1981 period (Table 20). The average escapement of 5,670 in that former time is less than 63% of the 2014 preliminary estimate of over 9,000 wild steelhead. Presumably if the tributaries were at former productivity levels present Skagit wild steelhead numbers would be considerably greater.

Table 19. Steelhead redds/km in three Mid Skagit tributaries in 1978-1981 compared to 2014

Stream	redds/km 1978-1981	redds/km 2014	present % of former spawning
Finney Ck	11.9	5.7	48%
Mill Ck	5.0-6.8	2.4	35-48%
O'Toole Ck	10.3-22.2	8.0	36-78%

Table 20. Skagit basin wild steelhead spawning escapements 1978-1981 and 2014

Year	Wild steelhead escapement	Reference
1978	7294	Phillips et al. 1981b
1979	3943	Phillips et al. 1981b
1980	6009	Phillips et al. 1981b
1981	5435	Phillips et al. 1981b
2014	over 9000, as preliminary estimate still to be finalized	per. comm. Brett Barkdull, WDFW, Nov. 6, 2014

Intermittent streams will increasingly be a part of the Northwest future if climate change progresses with continued warming at latitudes north of 45°N (Boughton et al. 2009). *O. mykiss* have adapted to this successfully and productively through much of their southern range and presumably a similar adaptation can transition northward as streams increasingly become intermittent over time. In fact, intermittent streams may even provide the most preferred spawning habitat due to having greater gravel accumulations (Everest 1973; Erman and Hawthorne 1976; Boughton et al. 2009) as occurs at Mill and Savage creeks of the Mid Skagit basin as a result of the probable mix of logging, landslides, increased flood events, and climate change. However, this adaptation and high level of potential productivity from intermittent streams will have to include early enough spawning for *O. mykiss* fry to get out of the gravel and migrate to perennial streams or perennial stream sections within the same streams for continued rearing.

There is a further consideration regarding intermittency and the use of such streams for successful wild steelhead reproduction. Although it was previously indicated that after significant portions had gone subsurface at Dry Creek with the assumption that potentially thousands of fry had perished by not outmigrating earlier, in the case of juvenile Atlantic salmon it has been found that juveniles, both fry and even parr size, can effectively penetrate the hyporheic flow of streams at least 60 cm (24 in) in both vertical and horizontal directions and may potentially include even more extensive movements (Heggenes et al. 2013). It was indicated that hatchery heritage fry may not be equally successful at doing so. At the level of benthic invertebrates, the hyporheic flow of rivers has been found to sustain connected communities 10 m (33 ft) deep and 2 km (1.24 mi) distant from the river channel within its more extensive floodplain (Stanford and Ward 1988). In the case of the Atlantic salmon fry, it indicated that finer sized substrates limited their movements more than larger sized substrates.

Dry Creek has considerable fine sediment in the gravel which may more restrict access to the hyporheic flow that otherwise likely includes both it and Finney Creek as part of an interactive floodplain. At both Dry Creek and Savage Creek, once they began to go subsurface digging down about 30 cm (12 in) did not reveal evidence of fry or parr, alive or dead, nor did the surface of the recently dewatered areas. However, the question remains: could they have been deeper, even a lot deeper? It remains for further consideration. Nevertheless, steelhead spawning time in the three tributaries that go intermittent in the Mid Skagit basin was earlier than the one regularly surveyed that remains perennial with apparent selection for earlier spawning by steelhead in the intermittent streams and likely earlier emergence as an adaptive advantage.

At Sagehen Creek in California, Erman and Hawthorne (1976) found that 39-47% of a rainbow trout population used an intermittent mountain stream to spawn despite the nearby presence of perennial stream habitat. On subsequent emergence the fry moved downstream to Sagehen Creek before the tributary dried up during a dry year (Erman and Leidy 1975). In a wetter year fry also moved downstream even though the streamflow remained permanent but many also remained as almost the only fish occupants of the stream. For whatever reasons that may not always be immediately identified, the intermittent tributary to Sagehen Creek example in California demonstrates the considerable attraction such streams have for *O. mykiss* spawning.

At the Arroyo Seco River, tributary of the Salinas River basin in central California, it was found that there was a spatial and temporal segregation of winter spawning habitat from over summering habitat as used by resident and anadromous *O. mykiss* (Boughton et al. 2009). The eastern side of the watershed was drier, the streams intermittent, spawning gravel aggregations greater, and spawning use was predominant; the western side of the watershed had more rainfall, cooler summer air temperatures, cooler streams with perennial flow, and resulting greater rearing use. It was considered that the fitness of the young-of-year hatching from the intermittent streams of the eastside depended on their ability to access the perennial westside tributaries for summer rearing before being lost to predation, warm temperatures, and intermittency. Of particular relevance to the Mid Skagit basin tributary creeks (Boughton et al. 2009):

Page 102: *"... suitably sized spawning gravels tended to occur in intermittent tributaries ... Significantly, some of the earliest-drying parts of the intermittent tributaries occurred just above their confluences, where they emerged from steep side canyons onto the unconstrained floodplain of the mainstem. This pattern cut off the possibility of emigration from intermittent creeks early in the seasonal drying process. This sort of bottom-up drying pattern might have greater mortality impacts than a top–down pattern, as the fish would retain a greater number of dispersal options for a longer time in the top–down pattern."*

Of further significance for recovery of ESA listed Puget Sound steelhead that includes the Mid Skagit basin:

Page 102: *"In many parts of their range, O. mykiss inhabit snow-fed mountain streams that more effectively store water for summer discharge than the rain-fed system observed in our study. However, many of these are expected to convert to rain-fed systems due to climate change. Under a given amount of annual precipitation, such conversion will produce larger peak flows in winter and lower minimum flows in summer."*

Page 92: "*In parts of North America, 59% of total stream length appears to be either intermittent or ephemeral (Nadeau & Rains 2007), and occurrence of intermittency may expand in the future as climate trends convert snowfed stream systems into rain-fed systems with reduced natural water storage and lower minimum flows. Such conversions are already in progress (Mote et al. 2005; Regonda et al. 2005; Hodgkins & Dudley 2006;*

Knowles et al. 2006), and are expected to affect most of the European, Asian and American continents north of 45°N ...”

A major question for the Mid Skagit basin tributary streams is what has happened to the formerly greater steelhead spawning use found 35 years ago? It is apparent that an increasing shift toward intermittency may not be a limitation on steelhead productivity, but may actually increase the amount of spawning gravel available. If steelhead can’t make effective use of these intermittent streams now, the future will likely only become worse until the present limitations in their steelhead productivity are effectively analyzed and rectified through fishery management changes and/or addressing other habitat constraints. This is particularly critical given that Skagit basin steelhead (and all those of Puget Sound) are ESA listed as Threatened with legal obligations intended for their recovery rather than perpetuating a continued slide toward further depletion. Given that wild steelhead escapements were actually higher in 2014 than in the period of 1978-1981, it is apparent that resolving the present limitations for tributary steelhead productivity in the Skagit basin would likely lead to considerable progress toward wild steelhead recovery.

More Heavily Used Mid Skagit Tributary Spawning Area Characteristics

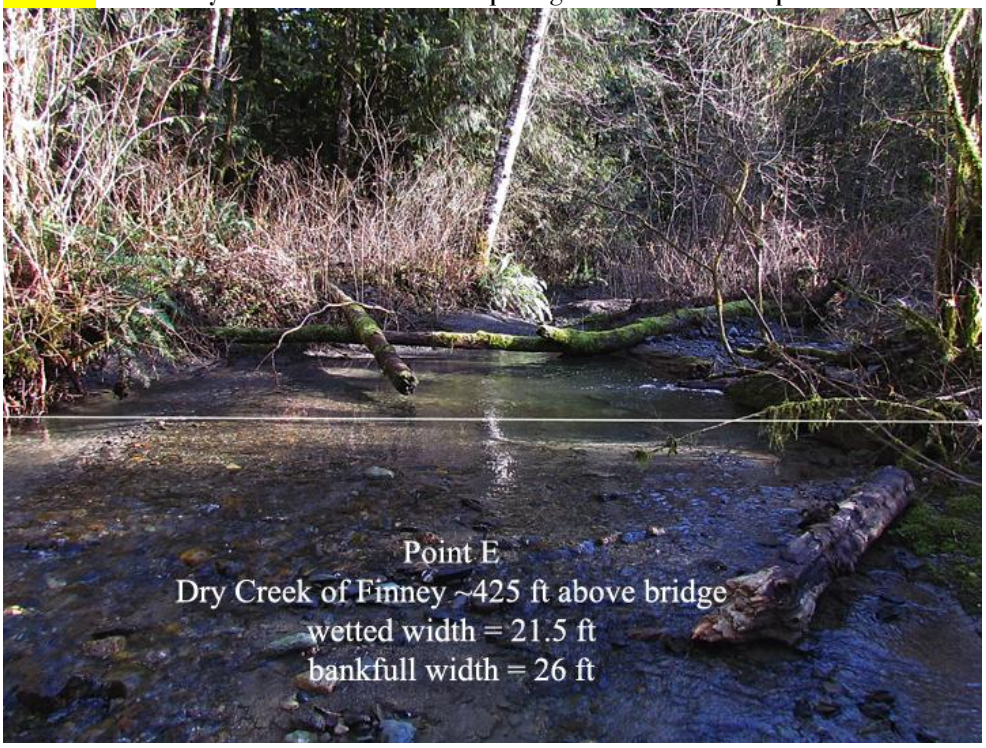
The one Mid Skagit tributary with proportionally greatest steelhead spawning use in 2014 was Dry Creek with about 14 redds per km (Table 4). Although Finney Creek overall had very dispersed steelhead spawning (less than 6 redds per km), there is a side channel below a logjam of about 150 m in length where 7-8 redds were found in a 40-50 foot (12-15 m) line (Appendix C, in Table 1) in a deep riffle with faster current speed than where most steelhead redds are found. These 7-8 redds were all a result of spawning that occurred in a relatively short period as found May 14, 2014 and photographed at a lower flow two days later (Photo 17). If this section was expanded to a length of 1 km it would result in 46 redds per km at 7 redds found, or 53 redds

Photo 17. A stable side channel at Finney Creek with 7-8 steelhead spawning redds in line

per km at 8 redds found if the majority of Finney Creek was similarly conformed. If this is further expanded to the approximate 10 km length of Finney Creek where winter steelhead spawning primarily occurs, it would result in 460-530 winter steelhead redds in the primary spawning area that may have once included many similar reaches as this 150 yard reach prior to the past 50 year logging history. This excludes whatever other redds may have occurred in this side channel due to the inability to effectively survey it during much of the earlier spawning season in 2014 due to high and/or discolored flows.

Dry Creek is a tributary of lower Finney Creek. Although it is of intermittent flow, it is the one tributary in the anadromous length of Finney basin that continues to have a considerable portion of its 800 m of anadromous length that is forested with conifer trees of larger second growth size. Perhaps as a result of this its channel is well contained (Photos 6 and 18). During the January through May spawning period the wetted width and bankfull width do not greatly differ (Table 21). This contrasts with Finney Creek that commonly has a very broad channel with great differences between wetted and bankfull widths during the steelhead spawning season that includes significant channel shifts during the higher flow events (Photos 2 and 3). Over the past five years of spawning surveys, the most contained and stable channel of Finney Creek in the lower anadromous reach is the side channel below the logjam that has been described. Although this side channel has been enlarging, it still remains well contained with little difference between wetted and bankfull widths during the steelhead spawning period. The steelhead use in this side channel as evidenced by redds has increased since the initial

Photo 18. Lower Dry Creek forested section depicting one of five channel points measured February 15, 2013



formation of this side channel shortly prior to, or near the same time, as the first 2009-2010 period of the initial year of the surveys.

One readily identified commonality between these two areas of Finney Creek's lower basin is their well contained channels during the steelhead spawning period as determined by the relatively small difference

between wetted and bankfull widths. The one other stream of the five Mid Skagit tributaries regularly surveyed that has a similarly well contained channel throughout its anadromous length is O'Toole Creek with 8 redds per kim, the second highest behind Dry Creek.

Table 21. Lower Dry Creek channel measures taken at five points on February 15, 2013

Dry Ck channel point of measure	Location	wetted width	bankfull width
A	34 ft below the Finney logging road bridge	12-13 ft	19-20 ft
B	8 ft above the Finney logging road bridge	11 ft	14 ft
C	90-100 ft above the Finney logging road bridge	9.5 ft	25 ft
D	~275 ft above the Finney logging road bridge	5.5 ft	38 ft
E	~425 ft above the Finney logging road bridge	21.5 ft	26 ft

Regarding streamflows, although no measuring gages occur at either stream, it has been apparent during the surveys that Dry Creek does not react as significantly as Finney Creek to rainfall, that it clears quickly after peak flows (unlike Finney), and that peak flows quickly subside (unlike Finney). The Finney Creek side channel, however, remains wetted longer into the summer period than Dry Creek, and may remain wetted throughout (although it has not been field checked in July and August). This alone would not make later steelhead spawning a reproductive disadvantage in the way it may be at Dry Creek. Regarding this, the 2014 finding of six steelhead redds in the first 12 days of May at Dry Creek, of which five were likely constructed in that period (Table 3; and Appendix C in Table 1), was unexpected given the late June period when it goes intermittent with disconnection from Finney Creek. Furthermore, all but one of these redds was in the stream section that went subsurface June 27th to July 13th in 2014. Spawning at that late date may be at great risk for reproductive success, yet it occurred. Apparently enough years occur when emergent fry can move downstream or upstream to sustain the significant evidence of spawning in May prior to mid month. It has to be a reproductive strategy that is at the thin edge of adaptation to Dry Creek, but which would be anticipated to be an entirely reliable strategy at the one Finney Creek side channel. Another possibility is that Dry Creek's stable channel may result in attraction of straying Finney Creek steelhead searching for more stable spawning sites than are provided by the commonly shifting channels at Finney Creek and associated potential risk through even lower reproductive success they are trying to avoid.

Although sediment levels in the gravel spawning areas were not measured at either Finney or Dry creeks, sediment appears to be particularly high at Finney Creek. However, sediment in the gravel at Dry Creek is not insignificant and may be finer and more compacted than at Finney.

O'Toole Creek, with the second highest steelhead spawning redd density per km, has a relatively confined channel and stable riparian area, in this case of older deciduous trees. Although a great difference between wetted and bankfull widths is not apparent, it is subject to high velocity peak flows due to the majority of the watershed being high gradient and in immediate proximity to the short, lower gradient anadromous area available. Nevertheless, it appears to have the least sediment in the gravel of the five Mid Skagit tributaries regularly surveyed. The gravel, however, in the areas that the steelhead primarily use for spawning is commonly limited to patches at stream edges and behind boulder pockets due to its higher gradient channel and common presence of boulders and large cobble. Yet, pink salmon numbering in hundreds in stronger return years find sufficient gravel to spawn without apparent over crowding (Appendix C, in Tables 1, 3, and 5), and Chinook salmon can number in the dozens (Appendix C, in Table 2). As indicated previously, it is the only

stream of the five regularly surveyed that throughout its anadromous length is perennial inclusive of the channel splits, what few there are. As with Dry Creek and the one side channel at Finney Creek, the one most apparent commonality is a confined channel. In size of channel and streamflow volume, it is considerably larger than Dry Creek with a channel width likely 2-4 times greater depending on area, but which has not been measured.

Of the Mid Skagit tributary streams regularly surveyed, it is Dry Creek that particularly stands out for the amount of steelhead spawning it sustains. Of considerable concern is the potential threat of what the loss of the older second growth forest, much of which is western red cedar, along its lower reaches might result in for steelhead with its potential loss and for lower Finney basin overall if Dry Creek's present use for steelhead spawning were to diminish. There is no stream area in lower Finney Creek that has a similarly retained forested section. The only section with a similarly confined channel is the 150 m side channel of Finney Creek in which its present stability is likely a result of a logjam that has built above it. Unfortunately, this side channel is likely a temporary feature as evidenced by its trend toward enlargement and inevitable movement of the protective logjam due to the stream channel instability surrounding it both upstream and down.

Future Spawning Related to Monthly Precipitation, Temperature and Streamflow Based on Historical Evidence

The over 100 year weather records from a fish collection station on the lower Baker River of the Mid Skagit basin near Concrete, WA provide the opportunity to make comparisons of mean monthly precipitation (Table 22) and air temperatures (Table 23) from 1909 to the present (a gap in data from 1916 to 1930). If broken into three 25 year periods from 1931 to 2005, a 7 year period from 1909 to 1915, and a 9 year period from 2006 to 2014 changes in precipitation and temperature can be determined as being positive (increasing), negative (decreasing), or neutral (little changed or an undetermined) trends over time. This can be estimated by subtracting the lowest reading from the highest each month for each period of time and if these readings are primarily progressing over time in an increasing or decreasing manner across the years of record. This results in a plus, minus, or erratic (essentially neutral) range of differences in readings across years for each month.

Table 22.
Mean Monthly Precipitation (inches) at Concrete, WA of Mid Skagit Basin over Five Periods (1909 to 2014); the Range of Monthly Differences and if Mostly Positive, Negative, or Neutral; and the Precipitation Trend

Positive monthly mean precipitation increasing over time
Negative monthly mean precipitation decreasing over time
Neutral monthly mean precipitation remaining little changed or of undetermined trend over time

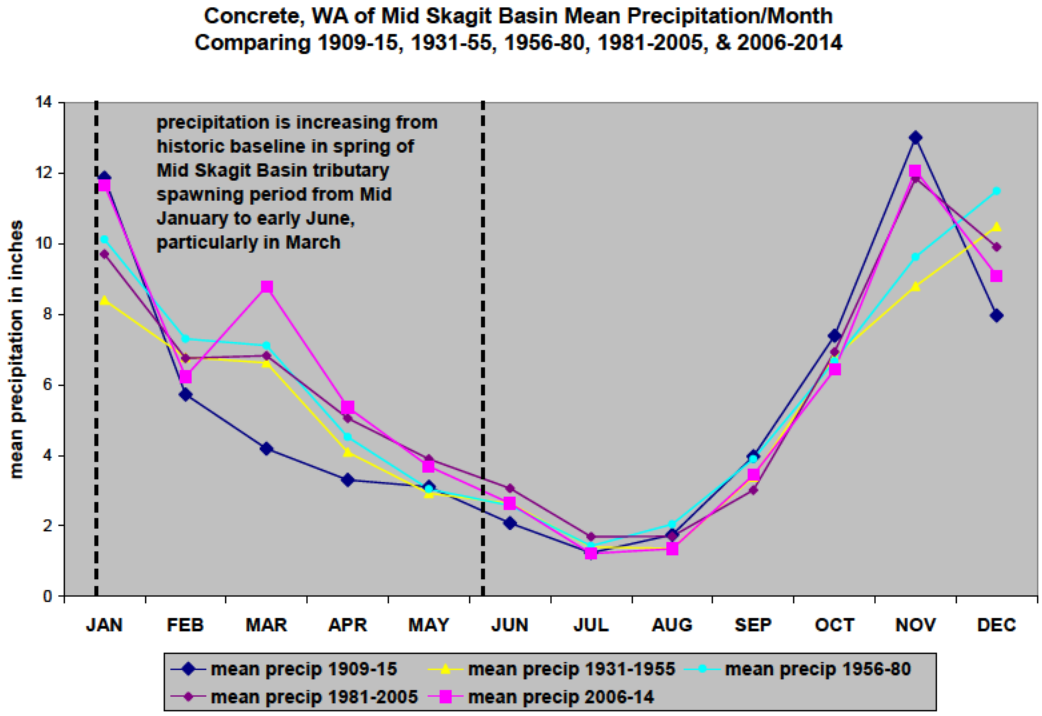
Time Period	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Annual Mean
1909-15	11.87*	5.72	4.18	3.30	3.10	2.08	1.23	1.75	3.97	7.39	13.01*	7.96	65.57
1931-55	8.40	6.78	6.62	4.09	2.92	2.63	1.39	1.36	3.39	6.79	8.80	10.49	63.66
1956-80	10.12	7.30	7.11	4.52	3.04	2.57	1.43	2.04	3.89	6.67	9.62	11.49	69.83
1981-2005	9.70	6.75	6.82	5.05	3.89	3.06	1.69	1.70	3.01	6.93	11.85	9.91	70.37
2006-14	11.66	6.23	8.79	5.36	3.69	2.64	1.21	1.35	3.44	6.43	12.08	9.10	71.97
Range Difference	±3.47 +3.26	±1.58	+4.61	+2.06	+0.97	±0.98	±0.48	±0.69	±0.96	-0.96	±4.21 +3.28	±3.53	+8.37
Trend	neutral higher	neutral	higher	higher	higher	neutral	neutral	neutral	neutral	lower	neutral higher	neutral	higher

* Excluding the 7-year period of 1909-15 for January and November results in a progressive increase in precipitation over time, but if that 7-year period is included it is a more neutral pattern of precipitation over time. The 7-year period may be too short to provide as good indication as the three 25-year periods of time from 1931 to 2005.

In the case of precipitation (Table 22 and Figure 37) five months of the year (January, March, April, May, and November show a generally increasing trend over time as does the annual mean. In the cases of January and November of the 7-year 1909-1915 period, the precipitation amount was as high or higher than in the most recent 2006-2014 period, but excluding those earliest 7 years of data the trend is more definitely increasing. It is unknown if the 7-year period of 1909-1915 was reflective of precipitation over the longer 25 year span that would have gone back another 18 years if it had been available. Nevertheless, the annual mean precipitation data indicates it is indeed increasing in annual total amount over time. The Mid Skagit basin is apparently getting wetter and especially so in the steelhead spawning period found in the Mid Skagit tributaries of January through May as the primary spawning months, the exception being February in which precipitation is remaining quite stable. The one month in which precipitation is increasing the most is March (an increase of 4.61 inches at this time from that of 1909-1915) followed by April (increase of 2.06 inches) and May (increase of 0.97 inch). January precipitation is either increasing considerably or remaining neutral, dependent on whether the 1909-1915 data are included or not.

These are the precipitation changes that steelhead are presently adapting to and will continue to adapt to as climate change progresses in its effects on the Mid Skagit Basin if the past 100 year trend continues: generally increasing precipitation during their spawning period, especially in March, and with February the one month with the least change. February would be anticipated to provide steelhead spawning conditions most similar to what shaped their spawning time in the past 100 years regarding precipitation. March, on the other hand, would be the month with the most extreme shift in steelhead spawning conditions from those that shaped their spawning time in the past 100 years regarding precipitation. Precipitation in tributary streams whose drainage areas are dominated by low elevations would be a particularly anticipated driver of streamflows, but this may not be as much the case with tributaries dominated more by high elevations drainage areas that accumulate as snowfall that comes out at a later date as melt water.

Figure 37.



In the case of air temperatures (Table 23 and Figure 38) six months of the year (March, April, May, June, September, and December) show a generally decreasing trend over time as does the annual mean. In the cases of October, December, and the annual mean of the 7-year 1909-1915 period, the temperatures were slightly colder than in the most recent 2006-2014 period, but excluding those earliest 7 years of data the trend is more

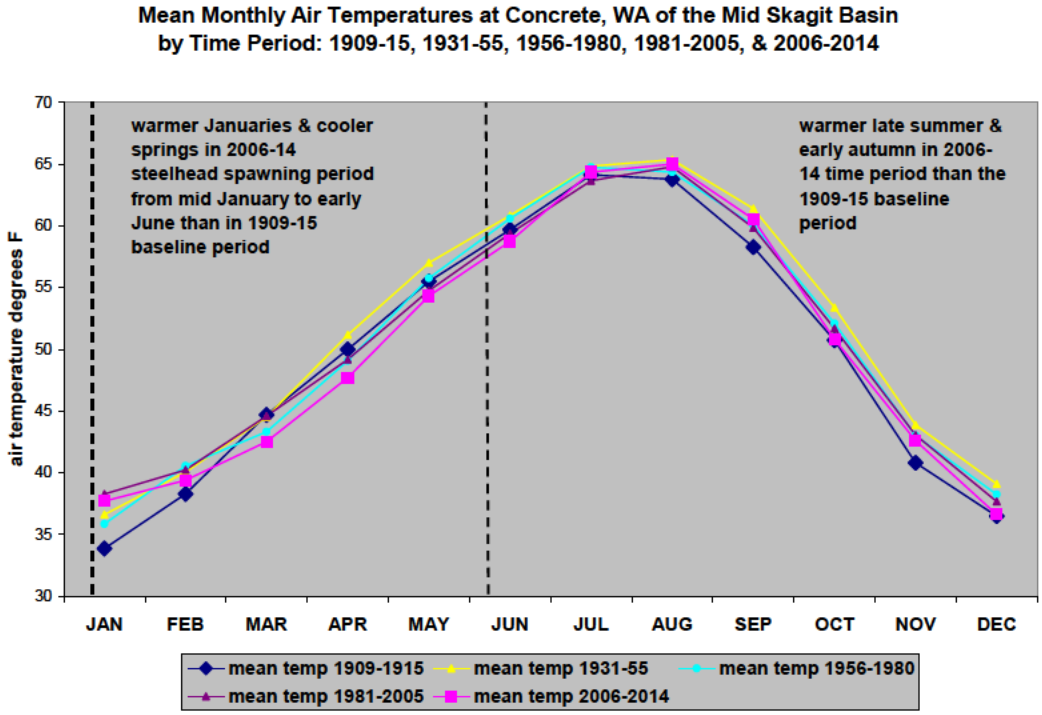
Table 23.
Mean Monthly Air Temperature (F) at Concrete, WA of Mid Skagit Basin over Five Periods (1909 to 2014); the Range of Monthly Differences and if Mostly Positive, Negative, or Neutral; and the Temperature Trend

Positive monthly mean temperatures increasing over time
Negative monthly mean temperatures decreasing over time
Neutral monthly mean temperatures remaining little changed or of undetermined trend over time

Time Period	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Annual Mean
1909-15	33.85	38.28	44.69	49.97	55.49	59.69	64.13	63.77	58.27	50.72*	40.80	36.48*	49.68*
1931-55	36.60	40.06	44.50	51.15	57.00	60.83	64.82	65.35	61.39	53.38	43.87	39.09	51.50
1956-80	35.85	40.56	43.31	49.06	55.75	60.58	64.76	64.35	60.04	52.09	43.00	38.24	50.63
1981-2005	38.26	40.23	44.59	49.16	54.74	59.37	63.65	64.78	59.84	51.67	43.04	37.65	50.58
2006-14	37.69	39.38	42.50	47.69	54.31	58.74	64.34	65.00	60.54	50.78	42.60	36.60	50.02
Range Difference	+4.41	±2.28	-2.19	-3.46	-2.69	-2.09	±1.17	±1.58	±3.12	±2.66 -2.6	±3.07	±2.61 -2.49	±1.82 -1.48
Trend	**higher**	**neutral**	**lower**	**lower**	**lower**	**lower**	**neutral**	**neutral**	**neutral**	**neutral lower**	**neutral**	**neutral lower**	**neutral lower**

* Excluding the 7-year period of 1909-15 for October, December, and the Annual Mean results in a progressive increase in air temperature over time in each of those columns, but if that 7-year period is included it is a more neutral pattern of precipitation over time. The 7-year period may be too short to provide as good indication as the three 25-year periods of time from 1931 to 2005.

Figure 38.



definitely decreasing. It is unknown if the 7-year period of 1909-1915 was reflective of temperatures over the longer 25 year span that would have gone back another 18 years if it had been available. Because the annual mean temperature data is in some question without a clear trend it can't be determined if there is an actual annual change over time. However, what is apparent is that in the full period of steelhead spawning of January to June found in the Mid Skagit tributaries that March (- 2.19 F), April (- 3.46 F), May (- 2.69 F), and June (- 2.09 F) are all getting cooler. Only January is warming, but very much so with a 4.41 F (2.45 C) increase in overall range, or 3.84 F (2.13 C) increase from 1909-15 period to 2006-14. February air temperatures, as with precipitation, are a relatively neutral trend.

These are the air temperature changes that steelhead are presently adapting to and will continue to adapt to as climate change progresses in its effects on the Mid Skagit Basin if the past 100 year trend continues: generally decreasing temperatures during their spawning period, especially in April (- 3.46 F, or - 1.92 C, as the overall temperature change range; - 2.28 F, or - 1.26 C, as the change between 1909-15 and 2006-14) and May (- 2.69, or - 1.50 C F, as the overall temperature change range; - 1.18 F, or - 0.66 C, as the change between 1909-15 and 2006-14), and with February the one month with the least change remaining relatively temperature-neutral. February would be anticipated to provide steelhead spawning conditions most similar to what shaped their spawning time in the past 100 years regarding temperatures. April and May, on the other hand, would be the months with the most extreme shifts in steelhead spawning conditions from those that shaped their spawning time in the past 100 years regarding temperatures that are lower. January, however, is the single month with the greatest temperature shift during the steelhead spawning period in its anomalous increase of 4.41 F (2.45 C) in the overall range, or 3.84 F (2.13 C) increase between 1909-15 and 2006-14. This is a January air temperature shift that would be anticipated to more regularly result in water temperatures that initiate steelhead spawning (3.9-4.0 C, or 39.02-39.20 F) as determined from Bell (1972) and Bovee (1978). The January warming would also be anticipated to result in less snowfall, particularly accumulations of snowpack at higher elevations at this winter date. Cooling in March and especially April, on the other hand, would increase the potential for snow and potentially result in an increasing snowpack at these late dates at higher elevations rather than what may have formerly been snowpack melt conditions. This will result in shifts in snowmelt accumulations at higher elevations in the Mid Skagit basin with stream hydrology shifts that steelhead spawning time is partially shaped by and will continue so into the future if the temperature trends remain on a similar path.

The 86 year streamflow records from the USGS gage between Arlington and Oso, WA on the North Fork Stillaguamish River provide the opportunity to make comparisons of mean monthly streamflows (in cfs) from 1928 to the present (Table 24 and Figure 39). If broken into three 25 year periods from 1928 to 2003 and a 12 year period from 2003 to 2014 changes in streamflow can be determined as being positive (increasing), negative (decreasing), or neutral (little changed or an undetermined) trends over time. As with precipitation and temperature, this can be estimated by subtracting the lowest reading from the highest each month for each period of time and if these readings are primarily progressing over time in an increasing or decreasing manner across the years of record. This results in a plus, minus, or erratic (essentially neutral) range of differences in readings across years for each month.

In the case of North Fork Stillaguamish River streamflow as a surrogate for that of Finney Creek and likely some other tributaries in the Mid Skagit basin (Table 24), four months of the year (January, March, April, and November) have a generally increasing trend over time. Although February has an erratic neutral trend over

time, the most recent period of 2003-2014 has sharply declined in streamflow. During the primary Mid Skagit tributary steelhead spawning period of January through May, January has the greatest shift in streamflow with an increase of 1,077 cfs from that of 1928-52, although this trend is not as steadily progressing as that of March (587 cfs increase) and April (218 cfs increase). As with January, November has had a large shift to increased flow. Overall, the once relatively even curves of streamflow in the 1928-52 period have become both erratic and extreme in the fall through spring period.

Table 24.

Mean Monthly Streamflow (cfs) at North Fork Stillaguamish River during Four Periods from 1928 to 2014; the Range of Monthly Differences and if Mostly Positive, Negative, or Neutral; and the Streamflow Trend

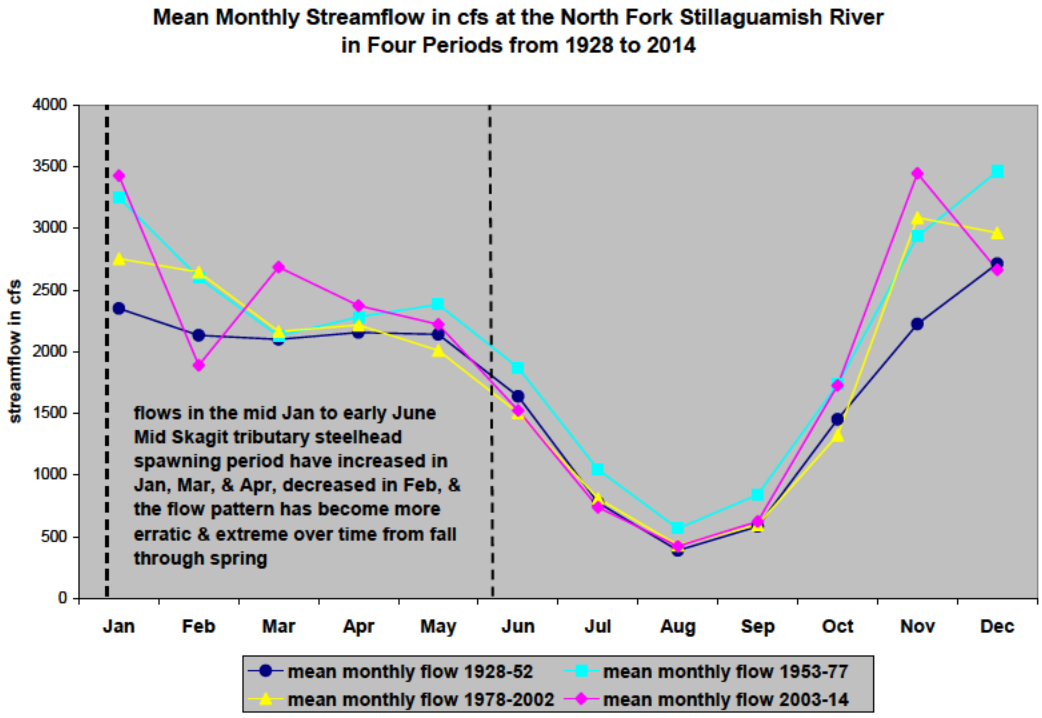
Positive monthly mean streamflows increasing over time

Negative monthly mean streamflowss decreasing over time

Neutral monthly mean streamflows remaining little changed or of undetermined trend over time

Time Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual mean
mean monthly flow 1928-52	2348	2132	2098	2154	2139	1637	775	389	583	1451	2223	2712	1720
mean monthly flow 1953-77	3249	2597	2127	2281	2382	1870	1045	566	840	1735	2934	3460	2090
mean monthly flow 1978-2002	2753	2644	2162	2216	2009	1504	809	431	596	1321	3085	2962	1875
mean monthly flow 2003-14	3425	1889	2685	2372	2220	1522	738	423	622	1726	3444	2663	1978
Range Difference	+1077	±755	+587	+218	±373	±366	±307	±177	±257	±414	+1221	±797	±370
Trend	**higher**	**neutral**	**higher**	**higher**	**neutral**	**neutral**	**neutral**	**neutral**	**neutral**	**neutral**	**higher**	**neutral**	**neutral**

Figure 39.



In the case of streamflow there are anthropogenic changes at the environmental level, such as widespread timber harvest, that may be more intensive in one period of time than another with a significant influence on how precipitation and air temperature affect streamflow in the North Fork Stillaguamish basin (and potentially differing considerably in the Mid Skagit basin by specific tributary). Although Figures 37 and 39 indicate that precipitation and streamflow patterns over the past 85-100 years have been generally similar during relatively comparable time periods, a more detailed analysis of this in the examination of timber harvest records may indicate a significant relationship that is not immediately apparent from the data used in the previous tables and figures.

Whatever the origins of streamflow shifts may be steelhead are adapting and will continue to adapt to these changes with spawn timing as climate change progresses, and which they have well enough adapted to in past climate shifts. Although this is a matter of magnitude of what the future may hold, at this point in time it would appear that through the present century Mid Skagit basin steelhead will not encounter stream characteristics that they have not successfully adapted to in the past 10,000-15,000 years after the Cordilleran ice sheet retreated from Puget Sound and steelhead again colonized the streams. What Mid Skagit tributary spawning wild steelhead did not encounter during past periods of climatic change were hatchery steelhead with reduced productivity levels that now inhabit their spawning grounds during significantly overlapping spawning periods. In the case of streamflows, the trend is toward more erratic monthly patterns with greater flow during the initiation of steelhead spawning in January, less flow in February, and increased flow in March and April for those tributary streams that may have similar monthly streamflow characteristics to the North Fork Stillaguamish River.

Steelhead Spawning, Streamflow, Precipitation, and Air Temperature at the Individual Tributary Level of Finney Creek

At the individual tributary level, Finney Creek is the largest of the five Mid Skagit tributaries that were regularly surveyed in the 2010-14 five year period. It is also the stream that drains the greatest amount of higher elevation areas in its watershed and with an historic streamflow record available from 1943 to 1948 (when it had a gaging station). Its streamflows have been found to be similar in monthly pattern to the North Fork Stillaguamish streamflows historically (Figure 26) and is thought to be similarly so today (Nichols and Ketcheson 2013). As a result Finney Creek provides time shots of the changes in streamflow patterns that have occurred between 1943-48 and 2010-14 as compared to the total number of steelhead redds counted at Finney Creek and adjusted to estimated spawning date from 2010 to 2014 (Figure 40). This further portrays the shifting streamflow trends that are particularly occurring in the steelhead spawning period of mid January to May at Finney Creek (and rarely to early June as found overall in the Mid Skagit tributaries). As previously indicated, the one month in the steelhead spawning period with flows that have remained more stable over time has been February from the streamflow data available that is at least in part representative of Mid Skagit tributaries.

Because there is no prior baseline of early spawning surveys from January to early March for comparison, what these streamflow shifts may have resulted in relative to steelhead spawning can't be determined. However, there is now such a baseline from which to make future comparisons as streamflows (and precipitation and temperatures) continue to shift over the coming years as will likely occur with continued climate change. The trend is for increasing streamflows during three (January, March, and April) of the four most important months

Figure 40.

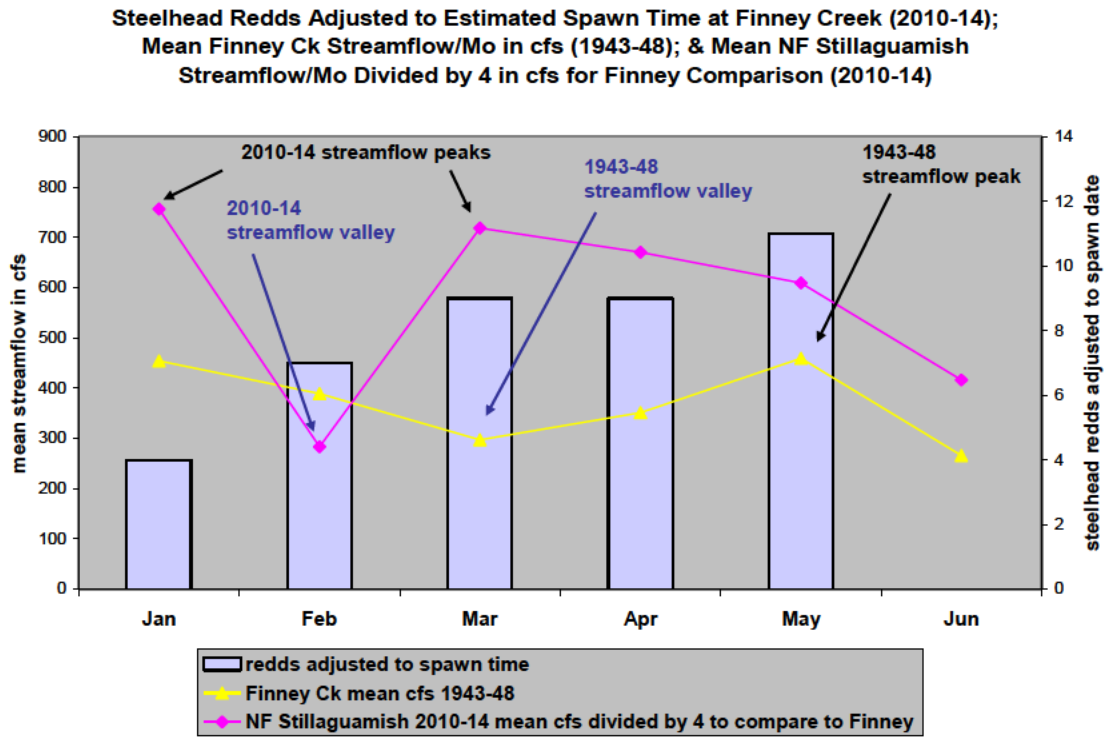
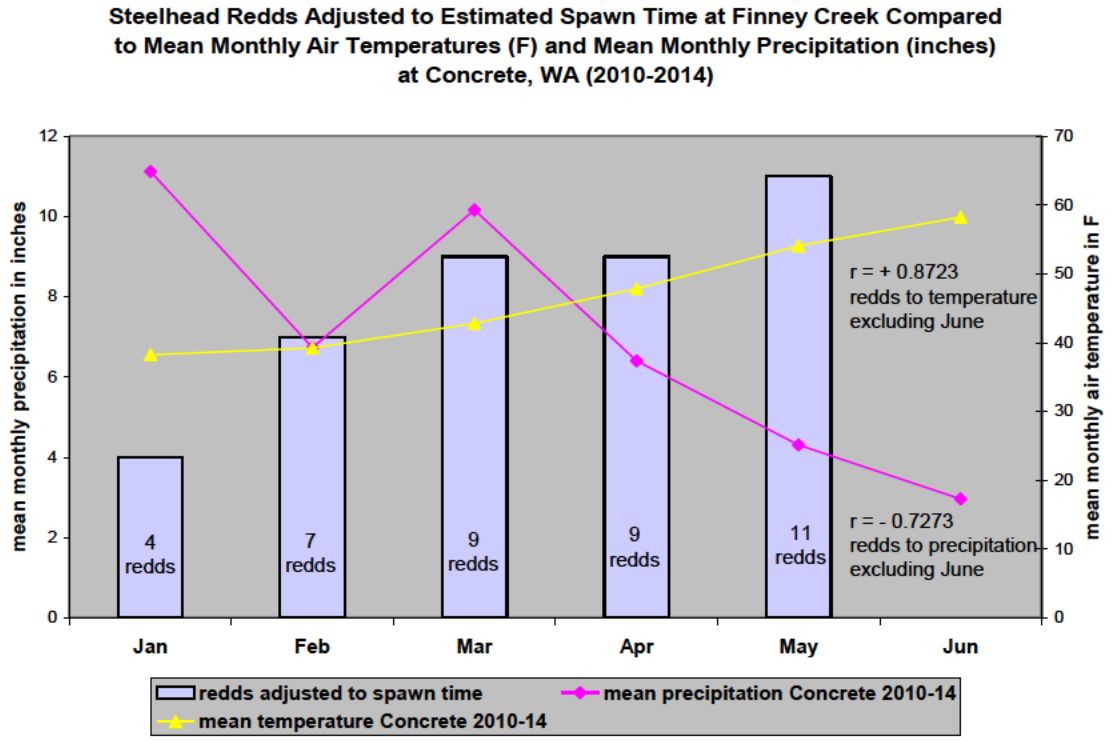


Figure 41.



for steelhead spawning (January, February, March, April, and May). The one month with the least streamflow change that may be particularly important for steelhead spawning adaptation through otherwise increasing streamflows is February if Finney Creek is a good representation for Mid Skagit basin tributaries. As previously determined, Finney Creek has perennial mainstem flow and important side channels used for spawning and/or rearing that have intermittent flow characteristics with resulting steelhead spawning that occurs both early and late (Figures 32 and 33) and does represent to some degree an intermediary stream in this regard. The potential relationship of streamflows to steelhead spawning at Finney Creek, however, is not a statistically significant correlation with a Pearson's "r" of - 0.2080 when excluding June or + 0.4385 when including June (when no redds were found). The actual relationship of streamflows to spawning likely requires more specific spawning dates than estimates of redd dates can provide because streamflows can significantly alter within one or two days of each other at Mid Skagit tributaries when significant precipitation occurs or ceases.

Furthermore, any specific flow may be of less relevance than any sudden rise in streamflow with precipitation followed by a decline when it subsides. This is when actual spawning entry has been observed to most often occur, not only at the Mid Skagit tributaries but elsewhere (Susac and Jacobs 1999).

Regarding precipitation and air temperature means per month at Concrete, Washington during the five year survey period at Finney Creek (Figure 41), there has been a positive correlation ("r" = + 0.8723) of steelhead spawning to air temperature if June is excluded as the outlier month when minimal steelhead spawning has been found in the Mid Skagit tributaries, and with no June evidence found at Finney Creek (although some likely occurs some years when cooler June air/water temeratures may occur). This is a significant correlation of increased spawning with increasing air temperature through May. Regarding precipitation, there has been a negative correlation to steelhead spawning ("r" = - 0.7273) as spawning has tended to be less with increased precipitation, but it is not a significant correlation. The month most out of alignment in the precipitation to spawning pattern has been March with its trend for increasing precipitation.

In the case of the precipitation to streamflow relationship, the choices between negative or positive anthropogenic changes related to the future of the Mid Skagit basin tributary streams may as well determine the adaptive future for steelhead as climate change itself, at least in this century. Anthropogenic change is not only related to habitat. The reproductive success for steelhead will be at least equally determined by decisions made regarding hatchery plants, commercial/sport/subsistence fisheries, and effective recovery of the range of historic life histories that formerly allowed *O. mykiss* to be such a productive species in the Skagit basin and which will determine their ability to reproductively adapt to future change or not across the full spectrum of temperatures, precipitation, and streamflows. Understanding the inherent range of characteristics of *O. mykiss* reproduction that have made them successful will only be determined by a future that includes effective monitoring of the amount, timing, and reproductive strategy shifts of combined anadrous/resident spawning in the vital tributary creeks of the larger basin where 65%-80% of former steelhead spawning occurred. This will also have to include the more obviously understood management of habitat, but preserving the necessary attributes of broad fish life histories needed to sustain themselves through continued change may well more quickly determine their fate (one way or the other) beyond that of habitat alone.

Among the more necessary attributes for reproductive success suggested by the Mid Skagit basin tributary surveys are: run timing; spawn timing; emergence timing; juvenile directional traits displayed shortly after emergence; and presence of resident males to insure fertilization that includes increased life history diversity. There are, of course, further determinations that can include female body size (that can determine redd depth),

female fecundity (not necessarily related to body size), diverse juvenile life histories with differing ages and migrational characteristics, and etc., but which were largely outside the ability of the spawning surveys to determine, and yet need to be determined. Many diverse characteristics thought to be inherited have thus far not been effectively identified through use of analytical genetic technology presently available. As a result identifying diverse life history characteristics in the field are necessary to identify those that evade lab detection. Unfortunately, lab identifications rather than field identifications have often become the primary means on which recovery decisions are based for steelhead. This includes common disregard for history (often depicting life history traits) to fill in biological puzzle parts needed on which to base recoveries sometimes available that date back a century or more.

Conclusion Essentials

The past five years of Mid Skagit basin surveys at five tributaries regularly surveyed for spawning steelhead, salmon, and cutthroat trout found the following:

- confirming old historical records steelhead spawning entry and spawning began in January, not March 15th as has been described in Puget Sound steelhead management documents in more recent history
- 104 steelhead redds were counted in the cumulative 2010-14 period; 49% of the redds were prior to March 15th; when redds were adjusted to estimated spawn time 53% were prior to March 15th
- coho salmon and steelhead have slight overlapping spawning times some years but typically minimal; sea-run cutthroat trout (and resident *O.clarki*) have significant spawning time overlaps with steelhead
- the tributary spawning populations include resident and anadromous *O. mykiss* life histories as well as probable sea-run and perhaps resident *O.clarkii*, with the resident proportions being males
- hatchery steelhead were included in the *O. mykiss* spawning population mix that includes mating with both resident and anadromous life histories and probably wild sea-run and resident *O.clarkii* males
- the proportion of hatchery steelhead actively spawning in the mid January to early June spawning period was a range of 29%-40%; if the wild male resident life history was included in the spawning mix the range was 22%-33% hatchery depending on if 2014 alone or that of 2010-14 cumulatively
- both wild and hatchery origin steelhead were found spawning in the early spawning period of mid January to mid March
- the proportion of hatchery steelhead actively spawning in the mid January to mid March spawning period was 67%; if the wild male resident life history was included in the spawning mix it was a range of 40%-50% hatchery depending on if 2014 alone or that of 2010-14 cumulatively
- although no hatchery steelhead were found spawning after March 15th the unknown origin steelhead after that date were 20% of the total steelhead then observed
- the spawning time of steelhead was found to differ by specific tributary with over 50% of the spawning occurring prior to March 15th at three of the tributaries regularly surveyed and with less than 50% at two
- potential reasons for differences in steelhead spawning time were examined and included differences in air/water temperature, precipitation, streamflow, and intermittent or perennial hydrology from data available with weather records dating to 1909 through the present and streamflows to 1928
- mean monthly air temperature, precipitation, and streamflow were compared to steelhead redd counts (and as adjusted to estimated spawning date) and then evaluated for Pearson's correlation coefficient "r" to determine if there was a significant relationship or not; although both water temperature and streamflow variables have been described by others as important factors in steelhead spawning time the correlations found generally proved to be erratic and not dependably significant; lack of the exact date of most spawnings and the need to use surrogate air temperature data for stream temperatures, and to use

precipitation and North Fork Stillaguamish River streamflow data as a substitute for missing stramflow data at each tributary surveyed may have confounded the ability to demonstrate statistically significant correlations to spawning time

- at the cumulative level of all five tributaries a highly significant correlation was found between average monthly air temperature and steelhead redds per month when adjusted to spawning date if 50-67% of the redds during the early spawning period were eliminated to better reflect wild steelhead spawning
- what water temperature data were taken indicated that steelhead spawning in warmer streams was skewed earlier and in colder streams skewed later; at one tributary with significant spawners in 2010 and 2014 the warmer year (2010) had a month earlier spawning peak than the colder year (2014)
- whether a tributary's hydrology was intermittent or perennial was found to be a particularly probable driver of steelhead spawning time differences regarding whether most was prior to March 15th or thereafter; this was hypothesized to be due to the need for spawning to be early enough for significant numbers of emergent steelhead fry to move either downstream to perennial waters prior to late June to early July when intermittent flows began to disconnect these tributaries from larger downstream water bodies (or upstream if that option was available)
- although intermittency is predicted to increase in northward expansion and is sometimes perceived as a great limitation on steelhead reproductive success, there are examples of great steelhead productivity that occurs in intermittent streams and where gravel accumulations may actually provide better spawning habitat if steelhead life histories have effectively adapted with early spawning and emergence
- steelhead fry emergence was first confirmed by late May at an intermittent tributary and another with side channels going intermittent as found in underwater photographs; steelhead fry in the photographs were likely present dating to at least mid May that could not be clearly identified; photographs earlier than early May did not occur that might have captured even April emergence
- shifts in the monthly pattern of air temperatures and precipitation since 1909 were examined as were streamflows dating to 1928; shifts are occurring that are particularly affecting the steelhead spawning period of January to May; the trends are toward warmer Januaries and neutral Februaries but cooler the other three months; more precipitation occurs each of the months but February; and greater streamflows occur except February and May; a former spring streamflow peak in May has shifted two months ahead to March; steelhead spawning must adapt to these climate changes; the one month with least change is February and may be an important point of stability
- regarding future genetic studies that may occur, it will be important to recognize the early period of time when steelhead fry emergence occurs and that the most likely time period for the hatchery signal to show up prior to significant depletion through natural selection would be fry sampling from May to mid June prior to probable high loss of hatchery and hybrid fry whose life histories may well exclude effective movements from intermittent streams, or stream sections, and vulnerability to predation or other factors that may commonly limit hatchery related characteristics to survive as well as wild
- of the five Mid Skagit tributaries regularly surveyed the one stream attribute identified that resulted in more intensive steelhead spawning use was a well contained channel with least difference between wetted and bankfull widths during the steelhead spawning period
- the Mid Skagit tributary surveys provide a baseline for the full period of steelhead spawning that has otherwise been lacking from which to monitor wild steelhead escapements, the hatchery component of the escapements, and how the steelhead spawning is variable in time and quantity by individual tributaries that have similarly variable environmental conditions that need to be understood and managed for in recovery planning

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Appendices
(A-G)

Appendix A.

Table 1.
Annual precipitation in inches near the mouth of Savage Creek and Birdsview, WA on the Mid Skagit River (2001-2014) with months of heaviest mean precipitation in light gray

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Mean
Jan		14.750	14.925	10.600	7.875	23.100	10.650	7.300	16.625	10.150	11.700	13.925	10.775	14.150	**12.810**
Feb		10.350	4.675	4.375	2.625	6.500	7.575	8.100	2.770	5.025	7.825	10.650	7.500	10.625	**6.815**
Mar		10.040	17.200	6.825	9.300	4.425	11.325	9.075	9.475	6.750	13.175	14.425	8.550	17.415	**10.614**
Apr		7.420	5.895	1.375	7.450	5.575	4.695	4.325	5.600	6.575	8.350	8.825	8.710	7.075	**6.298**
May		4.220	3.500	4.350	4.700	3.050	1.500	3.175	6.675	6.000	5.425	4.325	4.135	6.575	**4.433**
Jun		4.430	1.400	3.000	3.225	2.900	3.700	2.775	0.950	4.000	1.440	5.275	3.450	2.825	**3.028**
Jul		1.680	0.000	0.550	1.875	2.025	2.125	1.415	0.500	0.300	1.825	2.175	0.200	2.000	**1.282**
Aug		1.080	0.450	8.450	1.575	0.200	1.750	4.450	1.175	1.725	0.550	0.000	2.525	1.692	**1.994**
Sep		3.060	2.100	9.820	3.525	1.575	4.275	1.250	4.950	7.175	3.400	0.450	**12.150**		**4.478**
Oct	11.300	1.980	17.500	5.975	9.135	2.675	8.000	5.750	14.950	5.300	7.725	11.675	3.100		**8.082**
Nov	14.750	8.960	16.600	13.525	10.475	23.275	7.475	13.575	21.150	11.050	16.150	15.400	15.310		**14.438**
Dec	16.900	14.800	9.000	11.425	11.550	11.825	17.575	9.700	4.835	13.850	6.300	11.585	5.825		**11.167**
Total		**82.770**	**93.245**	**80.270**	**73.310**	**87.125**	**80.645**	**70.890**	**89.655**	**77.900**	**83.865**	**98.710**	**82.230**		**85.415**

Table 2.
Annual precipitation in inches at the lower Baker River near Concrete, WA on the Mid Skagit River (2001-2014) with months of heaviest mean precipitation in light gray

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Mean
Jan		11.820	11.730	9.530	6.610	20.180	7.990	6.350	14.850	9.550	14.090	12.000	9.270	10.700	11.128
Feb		8.440	3.740	3.650	1.900	7.140	5.860	7.380	2.030	4.680	6.110	9.380	5.200	8.280	5.676
Mar		7.840	13.940	6.610	7.230	4.080	9.750	7.290	7.140	5.730	11.730	11.620	7.650	14.080	8.822
Apr		7.030	5.400	0.930	5.890	4.690	3.820	3.410	4.340	5.830	7.190	5.200	7.210	6.570	5.193
May		3.210	3.850	3.600	3.590	2.510	1.620	2.880	4.670	5.850	3.730	4.140	3.410	4.390	3.650
Jun		3.700	0.930	2.370	3.130	2.370	3.110	2.370	1.090	3.260	1.460	4.220	3.330	2.540	2.606
Jul		1.110	0.080	0.710	1.630	1.940	1.590	0.910	0.000	0.200	1.910	2.180	0.060	2.130	1.112
Aug		1.120	0.550	6.680	0.970	0.220	1.490	3.970	1.360	0.580	0.210	0.010	2.250	2.040	1.650
Sep		1.900	1.550	8.760	3.440	1.660	2.290	1.460	3.110	7.380	2.180	0.330	9.080		3.595
Oct	10.080	1.360	15.220	5.010	6.840	2.600	8.040	4.040	13.530	4.740	5.500	9.880	3.080		6.917
Nov	10.930	6.940	14.170	11.040	9.380	19.650	6.280	11.910	16.510	9.800	12.590	11.250	8.650		11.469
Dec	13.170	10.610	7.870	9.730	8.250	11.090	13.230	9.630	4.330	11.310	4.330	12.010	6.850		9.416
Total		**65.080**	**79.030**	**68.620**	**58.860**	**78.130**	**65.070**	**61.600**	**72.960**	**68.910**	**71.030**	**82.220**	**66.040**		**69.796**

Appendix B.

Table 1. Skagit River Tributary Steelhead Egg Taking Operations 1914-1920 [tributary spawning steelhead averaged 2,855 eggs/female as found at Green River by Pautzke and Meigs (1941) and was used to estimate Skagit River tributary females from eggs taken]

Stream	Year	steelhead eggs	# females
Day Ck	1914	194,000	68
	1915	263,000	92
	1916	286,000	100
	1917	n/a	n/a
	1918	82,000	29
Grandy Ck	1913	2,679,000	938
	1914	829,000	290
	1915	1,800,000	630
	1916	3,212,000	1,125
	1917	290,000	102
	1918	3,043,000	1,066
	1919	226,400	79
	1920	255,000	89
Illabot Ck	1913	347,500	122
	1914	187,755	101
	1915	60,000	21
	1916	272,000	95
	1917	n/a	n/a
	1917-18	451,500	158

Appendix C.

Table 1. Mid Skagit Basin Spawning Survey Counts from October 3, 2013 to June 16, 2014 Made Regularly at Five Primary Index Streams: Savage, Mill, O'Toole, Finney, and Dry (of Finney) Creeks; and Rarely at Four other Streams: Quartz (of Finney), Hatchery (of Finney), Cumberland, and Grandy Creeks

Savage Creek redd counts							Savage Creek live and/or carcass counts					
date	**pink**	**chinook**	**chum**	**coho**	**steelhead**	**cutthroat**	**pink**	**chinook**	**chum**	**coho**	**steelhead**	**cutthroat**
Oct 1-7	25						206					
Oct 8-15	140			9			56			1		
Oct 16-23							46					
Oct 24-31												
Nov 1-7												
Nov 8-15				6						2		
Nov 16-23												
Nov 24-30				27						23		
Dec 1-7				24						20		
Dec 8-15												
Dec 16-23												
Dec 24-31			1	41		2			1	35		
Jan 1-7				14		1				17		
Jan 8-15				30						65		
Jan 16-23				32	1					16		
Jan 24-31				1		1				1		
Feb 1-7												
Feb 8-15												
Feb 16-23					2	1						
Feb 24-29												
Mar 1-7												
Mar 8-15					2	1						
Mar 16-23						1						
Mar 24-31												
Apr 1-7												
Apr 8-15												
Apr 16-23												
Apr 24-30												
May 1-7												
May 8-15												
May 16-23												
May 24-31												
Jun 1-7												
Jun 8-15												
Jun 16-23												
Total:	**165**		**1**	**184**	**5**	**7**	**308**		**1**	**180**		

Notes:

The pink salmon minimum escapement should be based on the redd count of Oct. 8-15 plus the live counts of Oct. 1-7 and Oct. 16-23. But actual escapement was likely greater due to likely missing earliest spawning in latter Sep.

On Jan. 23rd, the steelhead redd found was large and likely built between Jan. 4-14.

On Feb. 19th, the 2 probable steelhead redds found were likely built within the week; the cutthroat redd within 1-2 weeks all in Mainstem above WF Savage.

On Mar. 12th, one steelhead redd found near the mouth of Savage Ck., and on Mar. 15th another probable steelhead redd was found at WF Savage inside upper end of logging road culvert – the first probable steelhead redd ever found in WF Savage.

Mill Creek redd counts							Mill Creek live and/or carcass counts					
date	**pink**	**chinook**	**chum**	**coho**	**steelhead**	**cutthroat**	**pink**	**chinook**	**chum**	**coho**	**steelhead**	**cutthroat**
Oct 1-7	124	1					219	2	1			
Oct 8-15							416					
Oct 16-23												
Oct 24-31												
Nov 1-7												
Nov 8-15												
Nov 16-23				1						3		
Nov 24-30												
Dec 1-7				6						5		
Dec 8-15												
Dec 16-23												
Dec 24-31				15						5		
Jan 1-7				17						8		
Jan 8-15				14						19		
Jan 16-23												
Jan 24-31				6						3		
Feb 1-7												
Feb 8-15												
Feb 16-23												
Feb 24-29												
Mar 1-7												
Mar 8-15												
Mar 16-23												
Mar 24-31												
Apr 1-7												
Apr 8-15												
Apr 16-23												
Apr 24-30					2							
May 1-7												
May 8-15												
May 16-23												
May 24-31												
Jun 1-7												
Jun 8-15												
Jun 16-23												
Total:	**124**	**1**		**59**	**2**		**635**	**2**	**1**	**43**		

Notes:

The pink live and carcass counts were considered most accurate count, but a number of carcasses likely missed due to higher flows washing them out.

Coho escapement should be based on redds.

On April 30th, 2 redds were found both about 200 yds above S.Skagit Hwy; one about 2 wks old & other 3-7 days; first could have been cutthroat but date seemed more likely steelhead.

O'Toole Creek redd counts							O'Toole Creek live and/or carcass counts					
date	**pink**	**chinook**	**chum**	**coho**	**steelhead**	**cutthroat**	**pink**	**chinook**	**chum**	**coho**	**steelhead**	**cutthroat**
Oct 1-7	149						251					
Oct 8-15												
Oct 16-23												
Oct 24-31												
Nov 1-7												
Nov 8-15												
Nov 16-23												
Nov 24-30												
Dec 1-7												
Dec 8-15												
Dec 16-23												
Dec 24-31												
Jan 1-7												
Jan 8-15												
Jan 16-23												
Jan 24-31												
Feb 1-7												
Feb 8-15												
Feb 16-23												
Feb 24-29												
Mar 1-7												
Mar 8-15												
Mar 16-23												
Mar 24-31												
Apr 1-7					2	1						
Apr 8-15												
Apr 16-23												
Apr 24-30												
May 1-7					1							
May 8-15												1
May 16-23					1							
May 24-31												
Jun 1-7												
Jun 8-15												
Jun 16-23					1							
Total:	**149**				**5**	**1**	**251**					1

Notes:

Pink escapement should be based on the redd count of Oct. 1-7 plus the live count.

On April 7th, steelhead redd 3.5'x4' & 1-2 weeks old; sea-run cutthroat or resident rainbow redd was 16"x20" in quite large gravel & deep pit & about 1 week old.

On April 22nd, a WDFW steelhead flag marked 4-14-2014 had been considered on April 7th but not marked, it has been added to that survey; it would have been at least 1-2 weeks old at the earlier date.

On May 7th, a steelhead redd in a mid channel pocket was considered & then confirmed as one on May 11th; 2 other WDFW ribbons indicated redds that were highly questionable & unless active I could not count them.

On May 15th, a 15-18" male sea-run cutthroat in dark spawn colors was photographed with underwater camera in pool below falls pool.

On May 22nd, a small 1.5'x2.5' redd was found 200 yds above logjam, either small steelhead or large resident.

On June 16th, a steelhead redd of 1-2 weeks old was found about 80' below the barrier falls in mid-channel 4' x 10' around boulders.

Finney Creek redd counts							Finney Creek live and/or carcass counts					
date	**pink**	**chinook**	**chum**	**coho**	**steelhead**	**cutthroat**	**pink**	**chinook**	**chum**	**coho**	**steelhead**	**cutthroat**
Oct 1-7												
Oct 8-15												
Oct 16-23												
Oct 24-31												
Nov 1-7												
Nov 8-15												
Nov 16-23												
Nov 24-30												
Dec 1-7												
Dec 8-15												
Dec 16-23												
Dec 24-31												
Jan 1-7												
Jan 8-15												
Jan 16-23												
Jan 24-31												
Feb 1-7					1							
Feb 8-15												
Feb 16-23												
Feb 24-29												
Mar 1-7												
Mar 8-15												
Mar 16-23												
Mar 24-31					1						3	
Apr 1-7												
Apr 8-15					8							
Apr 16-23												
Apr 24-30												
May 1-7												
May 8-15					7							
May 16-23					3							
May 24-31												
Jun 1-7												
Jun 8-15												
Jun 16-23												
Total:					**20**						**3**	

Notes:

On Feb. 1st, the inactive steelhead redd found was likely constructed Jan. 28-30 shortly after rainfall brought creek up for entry.

On Mar. 28th, an active steelhead redd had at least a 32" female and 32-33" male on it and 18-20" resident or jack steelhead; there may have been another male steelhead and resident as well; visibility was limited by slight discoloration of water -- hatchery or wild origin could not be determined but sizes of main 2 suggested wild.

On April 14th, 8 inactive steelhead redds were found, 1 about a month old, 2 were about 3-4 weeks old, 2 were about 2-3 weeks old, 1 was about a week old, and 1 was just 1-3 days old.

On May 14th, 7-8 steelhead redds found in a long 45-50' line in side channel below logjam; 7 were counted as redds; 6 were likely made within the week and 1 maybe within 2 weeks.

On May 16th, 2 possible redds were found, one 200' below smolt trap site and one 100' below the logjam side channel; the redds were confirmed as such on May 30th.

On May 22nd, a new steelhead redd was found built within a few days below the logging road gate 3/8 mile.

Dry Creek (of Finney Creek) redd counts							Dry Creek Creek live and/or carcass counts					
date	pink	chinook	chum	coho	steelhead	cutthroat	pink	chinook	chum	coho	steelhead	cutthroat
Oct 1-7												
Oct 8-15												
Oct 16-23												
Oct 24-31												
Nov 1-7	47						31					
Nov 8-15												
Nov 16-23				5						8		
Nov 24-30												
Dec 1-7				1						1		
Dec 8-15												
Dec 16-23												
Dec 24-31				8		2				2		
Jan 1-7				7						5		
Jan 8-15				6						16		
Jan 16-23				8	1					17	1	
Jan 24-31												
Feb 1-7					2							
Feb 8-15												
Feb 16-23					1	2					2	2
Feb 24-29												
Mar 1-7												
Mar 8-15					2						2	
Mar 16-23												
Mar 24-31												
Apr 1-7												
Apr 8-15												
Apr 16-23												
Apr 24-30												
May 1-7					1	2						
May 8-15					5						2	
May 16-23												
May 24-31												
Jun 1-7												
Jun 8-15												
Jun 16-23												

Total:	**47**			**35**	**12**	**6**	**31**			**49**	**5**	**2**

Notes:

Pink and coho escapements should be based on redd counts.

On Jan 16th, the steelhead redd found was actively occupied by a hatchery female & resident male about 100' below the barrier falls.

On Feb 2nd, the steelhead redds found were likely made with rainfall entry on Jan 28-29.

On Feb 19th, the steelhead redd had a wild female on it but not actively digging; a male steelhead was actively chasing a resident rainbow or sea-run cutthroat male continuously away; in the same location as the Feb 19th steelhead sightings, on Feb 20th a pair of sea-run cutthroat were actively spawning with the male potentially the same as sighted with the steelhead the previous day.

On Mar 12th, the 2 steelhead redds found included one with a hatchery female, a probable wild male, and a 14" male resident rainbow just completing active spawning; they then migrated downstream – the female leaving the creek. It is possible that there was another active redd. A steelhead fled off it, but it is possible that it was the lingering male that had not fully gone out yet with the female. The potentially active redd was not counted..

On May 2nd, a steelhead redd of 3.5x3.5 ft of 3-7 days old was found and 2 smaller redds of 1.5'x1.5' each likely cutthroat or resident rainbow 1-2 weeks old.

On May 12th, 3 new inactive steelhead redds were found and 1 wild male and 1 wild female steelhead upstream of the redds. 4 more possible pocket redds were found that if so were likely created by one steelhead and were counted as one redd.

On May 14th, a possible steelhead redd was found at the log sill plunge pool where 2 live steelhead were sighted on the 12th. The redd confirmed on May 30th.

Quartz Creek (of Finney Creek) redd counts							**Quartz Creek live and/or carcass counts**					
date	**pink**	**chinook**	**chum**	**coho**	**steelhead**	**cutthroat**	**pink**	**chinook**	**chum**	**coho**	**steelhead**	**cutthroat**
Oct 1-7												
Oct 8-15												
Oct 16-23												
Oct 24-31												
Nov 1-7												
Nov 8-15												
Nov 16-23												
Nov 24-30												
Dec 1-7												
Dec 8-15												
Dec 16-23												
Dec 24-31												
Jan 1-7												
Jan 8-15												
Jan 16-23												
Jan 24-31												
Feb 1-7												
Feb 8-15												
Feb 16-23												
Feb 24-29												
Mar 1-7												
Mar 8-15												
Mar 16-23												
Mar 24-31												
Apr 1-7												
Apr 8-15												
Apr 16-23												
Apr 24-30												

May 1-7												
May 8-15												
May 16-23												
May 24-31												
Jun 1-7												
Jun 8-15												
Jun 16-23												
Total:												

Notes:

On May 16th, no evidence of steelhead spawning was found in the 200 yds surveyed above the Finney Ck Logging Rd bridge. The gravel was heavily sedimented with black colored sand and the gravel otherwise small quartz pebbles. The creek channel conformation above the bridge was otherwise good but of poor quality below the bridge as surveyed in past.

Hatchery Creek (of Finney Creek) redd counts							**Hatchery Creek live and/or carcass counts**					
date	**pink**	**chinook**	**chum**	**coho**	**steelhead**	**cutthroat**	**pink**	**chinook**	**chum**	**coho**	**steelhead**	**cutthroat**
Oct 1-7												
Oct 8-15												
Oct 16-23												
Oct 24-31												
Nov 1-7												
Nov 8-15												
Nov 16-23												
Nov 24-30												
Dec 1-7												
Dec 8-15												
Dec 16-23												
Dec 24-31												
Jan 1-7												
Jan 8-15												
Jan 16-23												
Jan 24-31												
Feb 1-7												
Feb 8-15												
Feb 16-23												
Feb 24-29												
Mar 1-7												
Mar 8-15												
Mar 16-23												
Mar 24-31												
Apr 1-7												
Apr 8-15												
Apr 16-23												
Apr 24-30												
May 1-7												
May 8-15												
May 16-23					2?							
May 24-31												
Jun 1-7												

Jun 8-15												
Jun 16-23												
Total:					2?							

Notes:

On May 16th, the 2 possible steelhead redds found were old and likely built 4-6 weeks earlier; 1 was 2.5'x3' and the other 2.5'x4' and potentially built by same fish if actual redds.

Cumberland Creek redd counts							**Cumberland Creek live and/or carcass counts**					
date	**pink**	**chinook**	**chum**	**coho**	**steelhead**	**cutthroat**	**pink**	**chinook**	**chum**	**coho**	**steelhead**	**cutthroat**
Oct 1-7												
Oct 8-15												
Oct 16-23												
Oct 24-31												
Nov 1-7												
Nov 8-15												
Nov 16-23												
Nov 24-30												
Dec 1-7												
Dec 8-15												
Dec 16-23												
Dec 24-31												
Jan 1-7												
Jan 8-15												
Jan 16-23												
Jan 24-31												
Feb 1-7												
Feb 8-15												
Feb 16-23												
Feb 24-29												
Mar 1-7												
Mar 8-15												
Mar 16-23												
Mar 24-31												
Apr 1-7												
Apr 8-15												
Apr 16-23												
Apr 24-30												
May 1-7					2							
May 8-15												
May 16-23												
May 24-31												
Jun 1-7												
Jun 8-15												
Jun 16-23												
Total:					**2**							

Notes:

On May 2nd, a probable steelhead redd of smaller size at 2.5'x3.5' was 2-3 wks old; a larger 6'x6' definite steelhead redd of same age was at same location as a WDFW steelhead redd ribbon dated 5-18-2012. This was at the end of the WDFW survey point.

Grandy Creek redd counts							Grandy Creek live and/or carcass counts					
date	**pink**	**chinook**	**chum**	**coho**	**steelhead**	**cutthroat**	**pink**	**chinook**	**chum**	**coho**	**steelhead**	**cutthroat**
Oct 1-7												
Oct 8-15												
Oct 16-23												
Oct 24-31												
Nov 1-7												
Nov 8-15												
Nov 16-23												
Nov 24-30												
Dec 1-7												
Dec 8-15												
Dec 16-23												
Dec 24-31												
Jan 1-7												
Jan 8-15												
Jan 16-23												
Jan 24-31												
Feb 1-7												
Feb 8-15												
Feb 16-23					1							
Feb 24-29												
Mar 1-7												
Mar 8-15												
Mar 16-23												
Mar 24-31												
Apr 1-7												
Apr 8-15												
Apr 16-23												
Apr 24-30												
May 1-7												
May 8-15												
May 16-23												
May 24-31												
Jun 1-7												
Jun 8-15												
Jun 16-23												
Total:					**1**							

Notes:

On Feb. 20th, the steelhead redd found was built within 7 days or less.

Table 2. Mid Skagit Basin Spawning Survey Counts from October 19, 2012 to April 20, 2013 Made Regularly at Five Primary Index Streams: Savage, Mill, Finney, and Dry (of Finney) Creeks; and Rarely at Four other Streams: O'Toole, Hatchery (of Finney), Pressentin, and Grandy Creeks

Savage Creek redd counts							Savage Creek live and/or carcass counts					
date	**pink**	**chinook**	**chum**	**coho**	**steelhead**	**cutthroat**	**pink**	**chinook**	**chum**	**coho**	**steelhead**	**cutthroat**
Oct 1-7												
Oct 8-15												
Oct 16-23												
Oct 24-31										2		
Nov 1-7												
Nov 8-15				6						2		
Nov 16-23				3						10		
Nov 24-30				35					2	63		
Dec 1-7				24						80		1
Dec 8-15												
Dec 16-23				7						15		
Dec 24-31												
Jan 1-7				1		6				1		
Jan 8-15				12						6		
Jan 16-23												
Jan 24-31												
Feb 1-7				14	1	10				2		
Feb 8-15					4	10				1		
Feb 16-23					2	1						
Feb 24-29												
Mar 1-7												
Mar 8-15												
Mar 16-23												
Mar 24-31												
Apr 1-7												
Apr 8-15					1							
Apr 16-23												
Apr 24-30												
May 1-7												
May 8-15												
May 16-23												
May 24-31												
Jun 1-7												
Jun 8-15												
Jun 16-23												
Total:				**102**	**8**	**27**			**2**	**182**		**1**

Notes:

14 older coho redds of 1-3 weeks old were found Feb. 5-8 & 1 new redd all in WF & uppermost Savage; the coho carcasses for same period were very old.

The steelhead redds found Feb. 5-8 all week to 10 days old.

The 2 steelhead redds of Feb. 23rd estimated 10-12 days old; the cutthroat redd was estimated at 7-10 days old; 2 small resident sized redds were also found that are not included.

The probable steelhead redd of April 14th was only 1-3 days old.

Mill Creek redd counts							Mill Creek live and/or carcass counts					
date	**pink**	**chinook**	**chum**	**coho**	**steelhead**	**cutthroat**	**pink**	**chinook**	**chum**	**coho**	**steelhead**	**cutthroat**
Oct 1-7												
Oct 8-15												
Oct 16-23		6	1					8	2			
Oct 24-31												
Nov 1-7												
Nov 8-15			9	6					10	4		
Nov 16-23												
Nov 24-30												
Dec 1-7												
Dec 8-15												
Dec 16-23												
Dec 24-31												
Jan 1-7				5								
Jan 8-15												
Jan 16-23												
Jan 24-31			1	1	4							
Feb 1-7												
Feb 8-15												
Feb 16-23					1							
Feb 24-29												
Mar 1-7												
Mar 8-15												
Mar 16-23												
Mar 24-31					4							
Apr 1-7												
Apr 8-15					1							
Apr 16-23												
Apr 24-30												
May 1-7												
May 8-15												
May 16-23												
May 24-31												
Jun 1-7												
Jun 8-15												
Jun 16-23												
Total:		**6**	**11**	**12**	**10**			**8**	**12**	**4**		

Notes:

Of the 4 steelhead redds found on Jan. 31st there were 3 below the bridge that were all built within 24 hr to a few days; the 4th was 300 yds above the bridge in a side channel where coho spawn but its newness & large size suggested steelhead redd.

The redd of Feb. 21st was estimated at less than 2 weeks old; size was marginal between cutthroat & steelhead but lower section of creek suggested latter.

Of the 4 steelhead redds on Mar. 27-28, 1 was less than a week old, the other 3 redds appeared to be about 2 weeks old.

The steelhead redd of Apr 13th was likely at least a week old.

O'Toole Creek redd counts							O'Toole Creek live and/or carcass counts					
date	**pink**	**chinook**	**chum**	**coho**	**steelhead**	**cutthroat**	**pink**	**chinook**	**chum**	**coho**	**steelhead**	**cutthroat**
Oct 1-7												
Oct 8-15												
Oct 16-23		21	6					16	10			
Oct 24-31												
Nov 1-7												
Nov 8-15												
Nov 16-23												
Nov 24-30												
Dec 1-7												
Dec 8-15												
Dec 16-23												
Dec 24-31												
Jan 1-7												
Jan 8-15												
Jan 16-23												
Jan 24-31												
Feb 1-7												
Feb 8-15												
Feb 16-23					1							
Feb 24-29												
Mar 1-7												
Mar 8-15												
Mar 16-23												
Mar 24-31												
Apr 1-7												
Apr 8-15												
Apr 16-23												
Apr 24-30												
May 1-7												
May 8-15												
May 16-23												
May 24-31												
Jun 1-7												
Jun 8-15												
Jun 16-23												
Total:		**21**	**6**		**1**			**16**	**10**			

Notes:

The steelhead redd found Feb. 21st was not there Feb. 1st & constructed between those dates; it was located 15' above mouth at Skagit.

Finney Creek redd counts							Finney Creek live and/or carcass counts					
date	**pink**	**chinook**	**chum**	**coho**	**steelhead**	**cutthroat**	**pink**	**chinook**	**chum**	**coho**	**steelhead**	**cutthroat**
Oct 1-7												
Oct 8-15												
Oct 16-23												

Oct 24-31		17	2					7	3			
Nov 1-7												
Nov 8-15												
Nov 16-23												
Nov 24-30												
Dec 1-7												
Dec 8-15												
Dec 16-23												
Dec 24-31												
Jan 1-7												
Jan 8-15												
Jan 16-23												
Jan 24-31												
Feb 1-7					1							
Feb 8-15				1	6							
Feb 16-23												
Feb 24-29												
Mar 1-7												
Mar 8-15												
Mar 16-23												
Mar 24-31												
Apr 1-7												
Apr 8-15												
Apr 16-23												
Apr 24-30												
May 1-7												
May 8-15												
May 16-23												
May 24-31												
Jun 1-7												
Jun 8-15												
Jun 16-23												
Total:		**17**	**2**	**1**	**7**			**7**	**3**			

Notes:

The redd of Feb. 2 was likely ~3 weeks old and large with deep pit in channel below logjam

The redd of Feb. 12 was likely built 5-10 days earlier & was 12' long by 5-6' wide not far above logging gate

Feb. 14th one redd was considered coho and 2-3 weeks old and 4' long by 2' wide and had algae on it; one redd was likely steelhead of 2-4 days old and 4' long by 2' wide; another likely steelhead redd was similarly fresh & 6' long by 4' wide

Feb. 15th one redd was 2-3 weeks old and 6' long by 5' wide, one was 2-3 weeks old and 4' x 4', and one was 2-4 days old and 8' long by 4' wide

Dry Creek (of Finney Creek) redd counts							Dry Creek Creek live and/or carcass counts					
date	**pink**	**chinook**	**chum**	**coho**	**steelhead**	**cutthroat**	**pink**	**chinook**	**chum**	**coho**	**steelhead**	**cutthroat**
Oct 1-7												
Oct 8-15												
Oct 16-23												
Oct 24-31												
Nov 1-7												

Nov 8-15												
Nov 16-23												
Nov 24-30												
Dec 1-7												
Dec 8-15												
Dec 16-23												
Dec 24-31												
Jan 1-7												
Jan 8-15												
Jan 16-23												
Jan 24-31												
Feb 1-7												
Feb 8-15				2	5	2						
Feb 16-23												
Feb 24-29						1						
Mar 1-7												
Mar 8-15												
Mar 16-23												
Mar 24-31												
Apr 1-7												
Apr 8-15												
Apr 16-23												
Apr 24-30												
May 1-7												
May 8-15												
May 16-23												
May 24-31												
Jun 1-7												
Jun 8-15												
Jun 16-23												
Total:				**2**	**5**	**3**						

Notes:

Of the 5 steelhead redds on Feb. 14th, 2 were probable built within 10 days; 3 were somewhat harder to determine due to being 3-4 weeks old.

Hatchery Creek (of Finney Creek) redd counts							**Hatchery Creek live and/or carcass counts**					
date	**pink**	**chinook**	**chum**	**coho**	**steelhead**	**cutthroat**	**pink**	**chinook**	**chum**	**coho**	**steelhead**	**cutthroat**
Oct 1-7												
Oct 8-15												
Oct 16-23												
Oct 24-31												
Nov 1-7												
Nov 8-15												
Nov 16-23												
Nov 24-30												
Dec 1-7												
Dec 8-15												
Dec 16-23												
Dec 24-31												

Jan 1-7												
Jan 8-15												
Jan 16-23												
Jan 24-31												
Feb 1-7												
Feb 8-15					1							
Feb 16-23												
Feb 24-29												
Mar 1-7												
Mar 8-15												
Mar 16-23												
Mar 24-31												
Apr 1-7												
Apr 8-15												
Apr 16-23												
Apr 24-30												
May 1-7												
May 8-15												
May 16-23												
May 24-31												
Jun 1-7												
Jun 8-15												
Jun 16-23												
Total:					**1**							

Notes:

The redd found Feb. 15th was considered to be 10-14 days old & size of 4 x 4.5 ft was maginal with cutthroat but redd depth suggested steelhead.

Grandy Creek redd counts							**Grandy Creek live and/or carcass counts**					
date	**pink**	**chinook**	**chum**	**coho**	**steelhead**	**cutthroat**	**pink**	**chinook**	**chum**	**coho**	**steelhead**	**cutthroat**
Oct 1-7												
Oct 8-15												
Oct 16-23												
Oct 24-31												
Nov 1-7												
Nov 8-15												
Nov 16-23												
Nov 24-30												
Dec 1-7												
Dec 8-15												
Dec 16-23												
Dec 24-31												
Jan 1-7												
Jan 8-15												
Jan 16-23												
Jan 24-31												
Feb 1-7												
Feb 8-15				2	5	2						

Feb 16-23												
Feb 24-29												
Mar 1-7												
Mar 8-15												
Mar 16-23												
Mar 24-31												
Apr 1-7												
Apr 8-15												
Apr 16-23												
Apr 24-30												
May 1-7												
May 8-15												
May 16-23												
May 24-31												
Jun 1-7												
Jun 8-15												
Jun 16-23												
Total:				**2**	**5**	**2**						

Notes:

Grandy steelhead redds of Feb. 11 looked 10-12 days old; coho redds looked a month old or more.

Pressentin Creek redd counts							**Pressentin Creek live and/or carcass counts**					
date	**pink**	**chinook**	**chum**	**coho**	**steelhead**	**cutthroat**	**pink**	**chinook**	**chum**	**coho**	**steelhead**	**cutthroat**
Oct 1-7												
Oct 8-15												
Oct 16-23												
Oct 24-31		1	11						19			
Nov 1-7												
Nov 8-15												
Nov 16-23												
Nov 24-30												
Dec 1-7												
Dec 8-15												
Dec 16-23												
Dec 24-31												
Jan 1-7												
Jan 8-15												
Jan 16-23												
Jan 24-31												
Feb 1-7												
Feb 8-15												
Feb 16-23												
Feb 24-29												
Mar 1-7												
Mar 8-15												
Mar 16-23												
Mar 24-31												
Apr 1-7												

Apr 8-15												
Apr 16-23												
Apr 24-30												
May 1-7												
May 8-15												
May 16-23												
May 24-31												
Jun 1-7												
Jun 8-15												
Jun 16-23												
Total:		**1**	**11**						**19**			

Table 3. Mid Skagit Basin Spawning Survey Counts from October 14, 2011 to May 13, 2012 Made Regularly at Four Primary Index Streams: Savage, Mill, O'Toole, and Finney Creeks.

Savage Creek redd counts							**Savage Creek live and/or carcass counts**					
date	**pink**	**chinook**	**chum**	**coho**	**steelhead**	**cutthroat**	**pink**	**chinook**	**chum**	**coho**	**steelhead**	**cutthroat**
Oct 1-7												
Oct 8-15												
Oct 16-23												
Oct 24-31												
Nov 1-7												
Nov 8-15												
Nov 16-23												
Nov 24-30				60						112		1
Dec 1-7												
Dec 8-15												
Dec 16-23												
Dec 24-31												
Jan 1-7				16						15		1
Jan 8-15												
Jan 16-23												
Jan 24-31												
Feb 1-7												
Feb 8-15												
Feb 16-23												
Feb 24-29												
Mar 1-7						1						
Mar 8-15												
Mar 16-23												
Mar 24-31												
Apr 1-7												
Apr 8-15												
Apr 16-23												
Apr 24-30												
May 1-7												

May 8-15												
May 16-23												
May 24-31												
Jun 1-7												
Jun 8-15												
Jun 16-23												
Total:				**76**		**1**				**127**		**2**

Mill Creek redd counts							**Mill Creek live and/or carcass counts**					
date	**pink**	**chinook**	**chum**	**coho**	**steelhead**	**cutthroat**	**pink**	**chinook**	**chum**	**coho**	**steelhead**	**cutthroat**
Oct 1-7												
Oct 8-15												
Oct 16-23	41	3					48	3				48
Oct 24-31	4						4					4
Nov 1-7												
Nov 8-15												
Nov 16-23												
Nov 24-30												
Dec 1-7												
Dec 8-15												
Dec 16-23				14		2						
Dec 24-31												
Jan 1-7				16						8		
Jan 8-15				4						1		
Jan 16-23												
Jan 24-31												
Feb 1-7												
Feb 8-15												
Feb 16-23				1	1							
Feb 24-29												
Mar 1-7												
Mar 8-15												
Mar 16-23												
Mar 24-31												
Apr 1-7												
Apr 8-15												
Apr 16-23												
Apr 24-30												
May 1-7												
May 8-15												
May 16-23												
May 24-31												
Jun 1-7												
Jun 8-15												
Jun 16-23												
Total:	**45**	**3**		**35**	**1**	**2**	**52**	**3**		**9**		

Notes:

The salmon redds on Dec. 21st were first considered even mix of coho & chum but 2014 evidence suggests all coho; the cutthroat redds were smaller.

One large interconnected redd was considered a potential chum at time but 2014 suggests probable coho and counted such.

One inactive redd on Feb 20th had partial algae & considered coho due to age & smaller size; sthd redd large & week or less old.

O'Toole Creek redd counts							O'Toole Creek live and/or carcass counts					
date	**pink**	**chinook**	**chum**	**coho**	**steelhead**	**cutthroat**	**pink**	**chinook**	**chum**	**coho**	**steelhead**	**cutthroat**
Oct 1-7												
Oct 8-15	147						219					
Oct 16-23	24		4				55		8			
Oct 24-31												
Nov 1-7	3		2				3		4			
Nov 8-15												
Nov 16-23												
Nov 24-30												
Dec 1-7												
Dec 8-15												
Dec 16-23												
Dec 24-31												
Jan 1-7												
Jan 8-15												
Jan 16-23												
Jan 24-31												
Feb 1-7												
Feb 8-15												
Feb 16-23												
Feb 24-29												
Mar 1-7												
Mar 8-15												
Mar 16-23												
Mar 24-31												
Apr 1-7												
Apr 8-15												
Apr 16-23												
Apr 24-30												
May 1-7												
May 8-15												
May 16-23												
May 24-31												
Jun 1-7												
Jun 8-15												
Jun 16-23												
Total:	**174**		**6**				**277**		**12**			

Finney Creek redd counts							Finney Creek live and/or carcass counts					
date	**pink**	**chinook**	**chum**	**coho**	**steelhead**	**cutthroat**	**pink**	**chinook**	**chum**	**coho**	**steelhead**	**cutthroat**
Oct 1-7												

Oct 8-15												
Oct 16-23												
Oct 24-31	394	4					749	7				
Nov 1-7												
Nov 8-15												
Nov 16-23												
Nov 24-30												
Dec 1-7												
Dec 8-15												
Dec 16-23												
Dec 24-31												
Jan 1-7												
Jan 8-15												
Jan 16-23												
Jan 24-31												
Feb 1-7												
Feb 8-15												
Feb 16-23												
Feb 24-29												
Mar 1-7												
Mar 8-15												
Mar 16-23												
Mar 24-31												
Apr 1-7												
Apr 8-15												
Apr 16-23												
Apr 24-30												
May 1-7												
May 8-15												
May 16-23												
May 24-31												
Jun 1-7												
Jun 8-15												
Jun 16-23												
Total:	**394**	4					**749**	**7**				

Table 4. Mid Skagit Basin Spawning Survey Counts from November 20, 2010 to May 10, 2011 Made Regularly at Three Primary Index Streams: Savage, Mill, and Finney Creeks; and Rarely at Four other Streams: O'Toole, Quartz (of Finney), Hatchery (of Finney), and Grandy Creeks

Savage Creek redd counts							**Savage Creek live and/or carcass counts**					
date	**pink**	**chinook**	**chum**	**coho**	**steelhead**	**cutthroat**	**pink**	**chinook**	**chum**	**coho**	**steelhead**	**cutthroat**
Oct 1-7												
Oct 8-15												
Oct 16-23												
Oct 24-31												
Nov 1-7												

Nov 8-15												
Nov 16-23												
Nov 24-30												
Dec 1-7												
Dec 8-15				39						84		1
Dec 16-23												
Dec 24-31				2						1		
Jan 1-7												
Jan 8-15				13						10		
Jan 16-23				9	2					7	4	
Jan 24-31					1	1						
Feb 1-7												
Feb 8-15												
Feb 16-23												
Feb 24-29												
Mar 1-7												
Mar 8-15												
Mar 16-23												
Mar 24-31												
Apr 1-7												
Apr 8-15												
Apr 16-23												
Apr 24-30												
May 1-7												
May 8-15												
May 16-23												
May 24-31												
Jun 1-7												
Jun 8-15												
Jun 16-23												
Total:				**63**	**3**	**1**				**102**	**4**	**1**

Notes:

On the one active steelhead redd in Savage Ditch on Jan 19th there was a hatchery female; 2 males were downstream, 1 hatchery & 1 unknown that fled; next day the redd was greatly enlarged & hatchery female remained; a nearby red-flanked male fled -- possible coho but spots suggested steelhead

Steelhead redd found Jan 31 likely 7-9 days old

Mill Creek redd counts							**Mill Creek live and/or carcass counts**					
date	**pink**	**chinook**	**chum**	**coho**	**steelhead**	**cutthroat**	**pink**	**chinook**	**chum**	**coho**	**steelhead**	**cutthroat**
Oct 1-7												
Oct 8-15												
Oct 16-23												
Oct 24-31												
Nov 1-7												
Nov 8-15												
Nov 16-23												
Nov 24-30												
Dec 1-7												

Dec 8-15												
Dec 16-23			3	7								
Dec 24-31												
Jan 1-7												
Jan 8-15												
Jan 16-23												
Jan 24-31					2							
Feb 1-7												
Feb 8-15												
Feb 16-23					2							
Feb 24-29												
Mar 1-7												
Mar 8-15												
Mar 16-23												
Mar 24-31												
Apr 1-7												
Apr 8-15												
Apr 16-23												
Apr 24-30					1							
May 1-7					1							
May 8-15												
May 16-23												
May 24-31												
Jun 1-7												
Jun 8-15												
Jun 16-23												
Total:			**3**	**7**	**6**							

Notes:

The 2 redds found Jan 31st appeared to be 1-2 weeks old & would coincide with when steelhead spawned in Savage Ck.

The 2 redds found Feb 18 were large sized & built within the week; large stream channel changes due to flood on Jan 17th.

A fresh steelhead redd was intially found April 30 maybe built within a day or 2; a new redd just above & overlapping was found May 8th but was not there on May 7th -- apparently 2 different steelhead.

Table 5. Mid Skagit Basin Spawning Survey Counts from October 19, 2009 to May 13, 2010 Made Regularly at Four Primary Index Streams: Savage, Mill, O'Toole, and Finney Creeks; and Rarely at Three other Streams: Hatchery (of Finney), Cumberland, and Grandy Creeks

Savage Creek redd counts							**Savage Creek live and/or carcass counts**					
date	**pink**	**chinook**	**chum**	**coho**	**steelhead**	**cutthroat**	**pink**	**chinook**	**chum**	**coho**	**steelhead**	**cutthroat**
Oct 1-7												
Oct 8-15												
Oct 16-23												
Oct 24-31	23						33			2		
Nov 1-7												
Nov 8-15			2	5						15		
Nov 16-23			3	3					6	2		

Nov 24-30				38						36		
Dec 1-7				20						9		
Dec 8-15												
Dec 16-23				20						38		
Dec 24-31												
Jan 1-7												
Jan 8-15				2								
Jan 16-23				6								
Jan 24-31												
Feb 1-7												
Feb 8-15												
Feb 16-23						1						
Feb 24-29												
Mar 1-7												
Mar 8-15												
Mar 16-23												
Mar 24-31												
Apr 1-7												
Apr 8-15												
Apr 16-23												
Apr 24-30						3						
May 1-7												
May 8-15												
May 16-23												
May 24-31												
Jun 1-7												
Jun 8-15												
Jun 16-23												
Total:	**23**		**5**	**94**		**4**	**33**		**6**	**102**		

Mill Creek redd counts							**Mill Creek live and/or carcass counts**					
date	**pink**	**chinook**	**chum**	**coho**	**steelhead**	**cutthroat**	**pink**	**chinook**	**chum**	**coho**	**steelhead**	**cutthroat**
Oct 1-7												
Oct 8-15												
Oct 16-23	43		1				124		4			
Oct 24-31	39	2		1			110	2		1		
Nov 1-7												
Nov 8-15				4			2					
Nov 16-23			1							1		
Nov 24-30												
Dec 1-7												
Dec 8-15												
Dec 16-23												
Dec 24-31												
Jan 1-7												
Jan 8-15												

Jan 16-23				2								
Jan 24-31												
Feb 1-7				1								
Feb 8-15												
Feb 16-23												
Feb 24-29												
Mar 1-7												
Mar 8-15												
Mar 16-23												
Mar 24-31												
Apr 1-7												
Apr 8-15												
Apr 16-23												
Apr 24-30												
May 1-7												
May 8-15					3							
May 16-23												
May 24-31												
Jun 1-7												
Jun 8-15												
Jun 16-23												
Total:	**82**	**2**	**2**	**8**	**3**		**236**	**2**	**4**	**2**		

Notes:

Older redd found on Feb 4 likely that of coho; creek running 42 F at 2:30 pm.

On May 13th a small but deep probable steelhead redd of 2' x 1.5' was found about 2-3 weeks old; another probable steelhead redd of about 3' x 2' was found about a month old; & another 4' x 3' with 2 pits and was about a month old.

O'Toole Creek redd counts							**O'Toole Creek live and/or carcass counts**					
date	**pink**	**chinook**	**chum**	**coho**	**steelhead**	**bull trt**	**pink**	**chinook**	**chum**	**coho**	**steelhead**	**bull trt**
Oct 1-7												
Oct 8-15												
Oct 16-23												
Oct 24-31	60		2			1	221		8			
Nov 1-7												
Nov 8-15												
Nov 16-23												
Nov 24-30												
Dec 1-7												
Dec 8-15												
Dec 16-23												
Dec 24-31												
Jan 1-7												
Jan 8-15												
Jan 16-23												
Jan 24-31												
Feb 1-7					1							
Feb 8-15												

Feb 16-23												
Feb 24-29												
Mar 1-7												
Mar 8-15												
Mar 16-23												
Mar 24-31												
Apr 1-7												
Apr 8-15												
Apr 16-23												
Apr 24-30												
May 1-7												
May 8-15					2							
May 16-23												
May 24-31												
Jun 1-7												
Jun 8-15												
Jun 16-23												
Total:	**60**		**2**		**3**	**1**	**221**		**8**			

Notes:

A potential bull trout redd was found Oct. 28th at the tail of pool below the 1st falls; no salmon redds have been found that high up since or before.

A large probable steelhead redd on Feb. 3rd near entry to Skagit no more than week old; warm winter related to El Nino and O'Toole water temp 42F.

A steelhead redd was found downstream of the S. Skagit Hwy bridge with a ribbon marked the day before (5-12-2010) & estimated to be about a week old & was 3' x 2' with a deep single pit; a steelhead redd of similar size about 3 weeks old was found 150 yds below the bridge.

Finney Creek redd counts							**Finney Creek live and/or carcass counts**					
date	**pink**	**chinook**	**chum**	**coho**	**steelhead**	**cutthroat**	**pink**	**chinook**	**chum**	**coho**	**steelhead**	**cutthroat**
Oct 1-7												
Oct 8-15												
Oct 16-23												
Oct 24-31												
Nov 1-7												
Nov 8-15												
Nov 16-23												
Nov 24-30												
Dec 1-7												
Dec 8-15												
Dec 16-23												
Dec 24-31												
Jan 1-7												
Jan 8-15												
Jan 16-23												
Jan 24-31												
Feb 1-7					1							
Feb 8-15												
Feb 16-23												
Feb 24-29												

Mar 1-7				2	3						1+1?	
Mar 8-15					1							
Mar 16-23												
Mar 24-31												
Apr 1-7												
Apr 8-15					3							
Apr 16-23					1							
Apr 24-30					2							
May 1-7												
May 8-15												
May 16-23					2							
May 24-31												
Jun 1-7												
Jun 8-15												
Jun 16-23												
Total:												

Notes:

Large redd found Feb 6th probable steelhead 100' above logging gate; sampled for steelhead but only 10" wild steelhead nearing smolt stage caught; water temp was 44 F at 1:30 pm; mild year.

Active steelhead redd on Mar 4th near mouth of creek above Hatchery Ck; large probable wild female on it; the mate fled with wake & unknown steelhead or resident male; 10 days later expanded to vacated 2 redds.

Cumberland Creek redd counts							**Cumberland Creek live and/or carcass counts**					
date	**pink**	**chinook**	**chum**	**coho**	**steelhead**	**cutthroat**	**pink**	**chinook**	**chum**	**coho**	**steelhead**	**cutthroat**
Oct 1-7												
Oct 8-15												
Oct 16-23												
Oct 24-31												
Nov 1-7												
Nov 8-15												
Nov 16-23												
Nov 24-30												
Dec 1-7												
Dec 8-15												
Dec 16-23												
Dec 24-31												
Jan 1-7												
Jan 8-15												
Jan 16-23												
Jan 24-31												
Feb 1-7												
Feb 8-15												
Feb 16-23												
Feb 24-29												
Mar 1-7												
Mar 8-15												
Mar 16-23												

Mar 24-31												
Apr 1-7												
Apr 8-15												
Apr 16-23												
Apr 24-30												
May 1-7												
May 8-15												
May 16-23												
May 24-31												
Jun 1-7												
Jun 8-15												
Jun 16-23												
Jun 24-30												
Jul 1-7					3							
Total:					**3**							

Notes:

While sampling Cumberland Ck on June 25th a steelhead redd marked on April 19th was still visible; 2 other unmarked redds were found further upstream another 450 yds, both very large and 4-5 weeks old & probably steelhead.

Grandy Creek redd counts							**Grandy Creek live and/or carcass counts**					
date	**pink**	**chinook**	**chum**	**coho**	**steelhead**	**cutthroat**	**pink**	**chinook**	**chum**	**coho**	**steelhead**	**cutthroat**
Oct 1-7												
Oct 8-15												
Oct 16-23												
Oct 24-31												
Nov 1-7												
Nov 8-15												
Nov 16-23												
Nov 24-30												
Dec 1-7												
Dec 8-15												
Dec 16-23												
Dec 24-31												
Jan 1-7												
Jan 8-15												
Jan 16-23												
Jan 24-31												
Feb 1-7												
Feb 8-15					1	1						
Feb 16-23												
Feb 24-29												
Mar 1-7												
Mar 8-15												
Mar 16-23												
Mar 24-31												
Apr 1-7												
Apr 8-15												

Apr 16-23												
Apr 24-30												
May 1-7												
May 8-15												
May 16-23												
May 24-31												
Jun 1-7												
Jun 8-15												
Jun 16-23												
Total:					**1**	**1**						

Notes:

On Feb 8th a probable steelhead redd found midway between Cape Horn Rd bridge and mouth; water temp was 44 F at 2:30 pm.

Appendix D.

Skagit River Peak Flows as Measured at USGS Gage 12194000 Near Concrete, WA (1948-2007)

Floods over 90,000 cfs

Floods over 140,000 cfs

water year	date	gage height (feet)	stream flow (cfs)	water year	date	gage height (feet)	stream flow (cfs)
1948	Oct. 19, 1947	32.99	95,200[6]	1978	Dec. 02, 1977	29.27	70,300[6]
1949	May 13, 1949	26.97	55,700[6]	1979	Nov. 08, 1978	25.19	46,000[6]
1950	Nov. 27, 1949	40.80	154,000[6]	1980	Dec. 18, 1979	38.57	135,800[6]
1951	Feb. 10, 1951	38.99	139,000[6]	1981	Dec. 26, 1980	40.19	148,700[6]
1952	Jun. 05, 1952	24.80	43,500[6]	1982	Jun. 21, 1982	26.20	51,700[6]
1953	Feb. 01, 1953	28.61	66,000[6]	1983	Dec. 04, 1982	33.82	101,000[6]
1954	Oct. 31, 1953	27.39	58,000[6]	1984	Jan. 05, 1984	34.94	109,000[6]
1955	Jun. 11, 1955	27.10	56,300[6]	1985	Jun. 07, 1985	25.20	46,100[6]
1956	Nov. 03, 1955	34.48	106,000[6]	1986	Jan. 19, 1986	32.75	93,400[6]
1957	Oct. 20, 1956	27.84	61,000[6]	1987	Nov. 24, 1986	31.30	83,500[6]
1958	Jan. 17, 1958	24.38	41,400[6]	1988	Nov. 24, 1987	23.96	39,600[6]
1959	Apr. 30, 1959	32.36	90,700[6]	1989	Oct. 16, 1988	29.86	74,100[6]
1960	Nov. 23, 1959	32.17	89,300[6]	1990	Dec. 04, 1989	36.39	119,000[6]
1961	Jan. 16, 1961	30.61	79,000[6]	1991	Nov. 10, 1990	40.20	149,000[6]
1962	Jan. 03, 1962	26.82	56,000[6]	1992	Apr. 29, 1992	26.46	53,300[6]
1963	Nov. 20, 1962	35.73	114,000[6]	1993	May 13, 1993	23.95	39,300[6]
1964	Oct. 22, 1963	29.80	73,800[6]	1994	Mar. 03, 1994	23.39	36,500[6]
1965	Dec. 01, 1964	26.20	52,600[6]	1995	Dec. 20, 1994	27.55	59,800[6]
1966	May 06, 1966	23.43	36,800[6]	1996	Nov. 29, 1995	41.57	160,000[6]
1967	Jun. 21, 1967	29.59	72,300[6]	1997	Jul. 09, 1997	32.46	91,400[6]
1968	Oct. 28, 1967	31.41	84,200[6]	1998	Oct. 05, 1997	30.26	76,700[6]
1969	Jan. 05, 1969	25.82	49,500[6]	1999	Dec. 13, 1998	27.81	61,400[6]
1970	Nov. 04, 1969	23.77	38,400[6]	2000	Nov. 12, 1999	34.15	103,000[6]
1971	Jan. 31, 1971	27.90	62,200[6]	2001	Oct. 20, 2000	22.19	30,900[6]
1972	Jul. 13, 1972	32.54	91,900[6]	2002	Jan. 08, 2002	33.06	94,300[6]
1973	Dec. 26, 1972	25.83	49,500[6]	2003	Jan. 26, 2003	28.60	65,500[6]
1974	Jan. 16, 1974	30.75	79,900[6]	2004	Oct. 21, 2003	42.21	166,000[6]
1975	Dec. 21, 1974	27.16	57,500[6]	2005	Dec. 11, 2004	33.78	99,400[6]
1976	Dec. 04, 1975	36.88	122,000[6]	2006	Jan. 10, 2006	27.01	56,300[6]
1977	Jan. 18, 1977	27.31	58,400[6]	2007	Nov. 06, 2006	39.79	145,000[6]

Appendix E.

Skagit River winter steelhead harvests from 1961-62 to 1965-66 and 1974-75 (Phillips et al. 1981b)

Year	total harvest	% wild	wild harvest	hatchery harvest
1961-62	11782	100%	11782	0
1962-63	13638	86%	11729	1910
1963-64	22216	83%	18439	3777
1964-65	13324	81%	10792	2532
1965-66	16699	68%	11355	5344
1974-75	21731	70%	15212	6518

Appendix F.

Table 1.
Weather at Concrete, WA and Steelhead Redds Found by Day and Estimated Period When the Spawning Occurred in 2011 at Four Mid Skagit Basin Tributary Streams and When Active Spawning was Observed

Period of time when conditions likely stimulated steelhead spawning shaded gray Some of more relevant considerations in **bold**

Day	High	Low	Concrete	NF Stilly flow	Sthd redds	Sthd redds	Sthd redds	Sthd redds	Notes
	(°F)	(°F)	precip (inch)	(cfs)	Savage	Mill	O'Toole	Finney	
1-Jan-11	35.1	21.9	0	2,190					
2-Jan-11	37	24.1	0	2,080					
3-Jan-11	39	24.1	0	1,980					
4-Jan-11	39.9	25	0	1,910					
5-Jan-11	35.1	27	0.03	1,940					
6-Jan-11	37	34	**0.78**	**3,740**	0				only coho spawning found near Savage mouth
7-Jan-11	39.9	35.1	**0.98**	**7,090**					
8-Jan-11	43	35.1	**0.51**	**4,960**					
9-Jan-11	39.9	32	0.1	3,430	0				only coho spawning found upper Savage
10-Jan-11	37.9	28.9	0	2,810					
11-Jan-11	37	28.9	0	2,480					
12-Jan-11	36	30	**0.81**	2,650					
13-Jan-11	36	32	**0.76**	**6,870**					
14-Jan-11	39.9	35.1	**0.69**	**13,000**					
15-Jan-11	43	37.9	**0.62**	**7,810**					
16-Jan-11	43	39	**1.68**	**16,100**					
17-Jan-11	**50**	42.1	**2.83**	**20,400**					Skagit flow peaks **75,000cfs** making ease of entry to creeks; south side Skagit creeks very high
18-Jan-11	**46**	39	**0.72**	**6,710**					**14 days prior Jan 31**
19-Jan-11	39.9	36	0.08	3,680	1 active 2 inactive	0			Savage 42F, Mill 39F, Skagit 40F -- Mill Ck too high to wade upstream bridge
20-Jan-11	42.1	33.1	0	2,780	0				live male steelhead red sides of unknown origin at Savage; hatchery female still present with redd much enlarged
21-Jan-11	37	33.1	**0.97**	**4,590**	0				too high to survey ditch well; only redds thought to be coho in mid section above pond
22-Jan-11	**43**	36	**0.88**	**4,180**	0	0			only a coho carcass found below ditched section Savage
23-Jan-11	**45**	37.9	0.17	2,790					
24-Jan-11	**46.9**	39	0.32	2,700					
25-Jan-11	44.1	41	0.52	3,050					**7 days prior Jan 31**
26-Jan-11	48	41	0	2,370					
27-Jan-11	50	36	0	2,080					
28-Jan-11	46	35.1	0	2,030					
29-Jan-11	42.1	35.1	0.27	3,820					
30-Jan-11	46	33.1	0.37	3,330					
31-Jan-11	43	28.9	0	2,250	1 inactive	2 inactive			redd built after Jan 22 at Savage; 2 redds 7-14 days old at Mill & Jan 20 or Jan 23-24 thought most conducive conditions
1-Feb-11	39.9	27	0	1,850			0		
2-Feb-11	39.9	27	0	1,620					
3-Feb-11	44.1	28	0.03	1,510					
4-Feb-11	42.1	37.9	0.98	2,830					
5-Feb-11	46.9	39.9	0.54	2,610					
6-Feb-11	48	39.9	0.07	2,060					
7-Feb-11	46	39	0.49	3,300					
8-Feb-11	43	35.1	0.23	2,460					
9-Feb-11	46.9	28	0	1,920					
10-Feb-11	46	28	0	1,650					

11-Feb-11	48.9	28.9	0	1,500					
12-Feb-11	42.1	35.1	0.04	1,570					
13-Feb-11	**48.9**	39	**0.58**	**2,400**					
14-Feb-11	**50**	39	**0.17**	**2,230**					
15-Feb-11	**46.9**	37.9	**0.47**	**2,740**					**2.3" rain Birdisview Feb 13-15**
16-Feb-11	44.1	36	0.11	2,040					
17-Feb-11	46	32	0.15	1,760					
18-Feb-11	42.1	32	0.25	1,560	0	2 inactive			redds built within the week or past few days
19-Feb-11	46.9	28.9	0	1,390					
20-Feb-11	48	27	0	1,260					
21-Feb-11	44.1	27	0	1,190				0	
22-Feb-11	39.9	30.9	0.32	1,190					
23-Feb-11	41	28.9	0.4	1,130					
24-Feb-11	32	24.1	0.36	1,040					
25-Feb-11	34	16	0.12	934					
26-Feb-11	33.1	16	0	885					
27-Feb-11	28	19	0.32	906					
28-Feb-11	35.1	27	0.48	979					
1-Mar-11	36	32	0.23	919					
2-Mar-11	37.9	32	0.21	1,030					
3-Mar-11	48.9	34	0.22	1,150					
4-Mar-11	42.1	30.9	0.39	1,070					
5-Mar-11	37.9	30.9	0.51	1,370					
6-Mar-11	46.9	35.1	0.09	1,320					
7-Mar-11	46.9	30.9	0.03	1,160					
8-Mar-11	48	33.1	0.03	1,080					
9-Mar-11	42.1	33.1	**0.46**	1,440	0				only a possible cutthroat redd sighted; still snow on ground
10-Mar-11	42.1	37	**0.59**	**3,320**	0	0			
11-Mar-11	45	37	**0.53**	**3,450**					
12-Mar-11	45	37	**0.23**	**2,390**					
13-Mar-11	42.1	37	**0.19**	**2,620**					
14-Mar-11	44.1	37.9	**0.96**	**4,970**					**Skagit flow up to 20,000 cfs**
15-Mar-11	45	39.9	**0.26**	**3,990**					
16-Mar-11	44.1	39.9	**0.87**	**4,620**					
17-Mar-11	41	33.1	**1.18**	**3,460**					
18-Mar-11	48.9	33.1	0.03	2,580	0	0			despite Skagit being up to 20,000 on Mar 14 no new spawning entry found
19-Mar-11	53.1	34	0.28	2,220					
20-Mar-11	54	32	0	1,910					
21-Mar-11	55.9	32	0.12	1,730					
22-Mar-11	52	39	0.34	1,990					
23-Mar-11	53.1	32	0	1,670					
24-Mar-11	61	32	0	1,510					
25-Mar-11	64	32	0.06	1,500				0	
26-Mar-11	55	37	0.14	1,480					
27-Mar-11	57	36	0.18	1,450					
28-Mar-11	55	39.9	0.12	1,510					
29-Mar-11	53.1	39.9	0.18	1,700					
30-Mar-11	48.9	39.9	**0.92**	**8,460**					
31-Mar-11	44.1	39.9	**2.38**	**16,200**					**Skagit up to 33,500 cfs**
1-Apr-11	53.1	42.1	**0.24**	**6,840**					
2-Apr-11	44.1	39.9	**1.03**	**5,990**					
3-Apr-11	46.9	39	**0.25**	**4,030**					
4-Apr-11	48.9	36	**0.22**	**3,700**					
5-Apr-11	39.9	35.1	**1.04**	**4,150**					
6-Apr-11	44.1	37	**0.48**	**3,710**					Finney creek remaining high and dirty
7-Apr-11	46	33.1	0.1	2,860				0	too discolored to see much
8-Apr-11	53.1	33.1	0.01	2,340				0	better color with 12-14" visibility
9-Apr-11	55.9	33.1	0	2,100					
10-Apr-11	52	39.9	0.02	2,070					
11-Apr-11	46	39.9	**0.98**	**3,510**					Finney very dirty and high
12-Apr-11	48	37	**0.25**	**2,740**					
13-Apr-11	57.9	37	0	2,260					
14-Apr-11	54	37.9	0.18	2,130					
15-Apr-11	46.9	36	**0.47**	2,240					

16-Apr-11	46.9	35.1	0.22	2,410					Finney still too discolored to survey
17-Apr-11	48.9	35.1	0.12	2,300				0	above Rexall Ck relatively clear
18-Apr-11	52	32	0.03	1,960					
19-Apr-11	52	33.1	0.26	1,770					
20-Apr-11	52	33.1	0.07	1,610					
21-Apr-11	53.1	34	0.05	1,580	0	0		0	
22-Apr-11	46.9	35.1	0.18	1,490					
23-Apr-11	61	35.1	0	1,430					
24-Apr-11	70	36	0	1,440				0	
25-Apr-11	57	37.9	0.03	1,660				0	
26-Apr-11	**50**	39.9	**0.29**	**2,140**					
27-Apr-11	**57.9**	39.9	**0.21**	**1,980**				0	
28-Apr-11	**52**	37.9	**0.36**	**2,150**					**Birdsview gage had 0.625" rain in 36 hours**
29-Apr-11	50	36	0.07	**1,930**					
30-Apr-11	55.9	37.9	0.03	1,740	0	1 inactive			very fresh redd made that day or day before
1-May-11	55.9	36	0	1,620				0	
2-May-11	66	35.1	0	1,890					
3-May-11	48.9	42.1	0.32	2,670					
4-May-11	51.1	39	0.06	2,220					
5-May-11	**66**	37.9	0.08	2,120					
6-May-11	**54**	45	**0.15**	2,270					
7-May-11	**54**	45	**0.26**	**2,970**	0	0			**at Birdsview gage there was 0.60" rain;** Mill Ck high
8-May-11	51.1	44.1	**0.14**	**2,950**	0	1 inactive			right in front & beside redd of April 30th & not there previous day
9-May-11	**55.9**	44.1	0	2,320					
10-May-11	**57.9**	45	0	2,080	0	enlarged redd			the redd of May 8th had been enlarged
11-May-11	64.9	45	0.11	2,580					
12-May-11	53.1	39	0.47	3,450					
13-May-11	62.1	37.9	0	2,410					
14-May-11	75	39	0	2,420					
15-May-11	63	48.9	0.14	3,390					
Survey total					**16**	**11**	**1**	**10**	

Table 2.
Weather at Concrete, WA and Steelhead Redds Found by Day and Estimated Period When the Spawning Occurred in 2014 at Five Mid Skagit Basin Tributary Streams and When Active Spawning Was Observed

Period of time when conditions likely stimulated steelhead spawning shaded gray Some of more relevant considerations in **bold**

Day	**High**	**Low**	**Concrete**	**NF Stilly flow**	**Sthd redds**	**Sthd redds**	**Sthd redds**	**Sthd redds**	**Sthd redds**	**Notes**
	(°F)	(°F)	precip (inch)	(cfs)	Savage	Mill	O'Toole	Finney	Dry	
1-Jan-11	44.1	39.9	0.06	1,020						
2-Jan-11	44.1	37.9	0.19	1,050						
3-Jan-11	45	36	1.03	2,150						
4-Jan-11	43	33.1	0.02	1,380	0				1	
5-Jan-11	43	30.9	0	1,150	0	0				
6-Jan-11	39.9	30	0.02	1,040						
7-Jan-11	39.9	32	0.07	1,430						
8-Jan-11	41	37	**0.65**	**2,790**						
9-Jan-11	43	39.9	**0.93**	**3,590**						
10-Jan-11	45	37	**0.67**	**3,630**		0			0	
11-Jan-11	46.9	37	**2.06**	**11,500**						
12-Jan-11	**46.9**	41	**0.96**	**7,070**						
13-Jan-11	**46**	36	**1.64**	**10,100**						
14-Jan-11	**46.9**	44.1	**1.44**	**7,240**	0					
15-Jan-11	**48**	42.1	0.03	**3,560**	0	0				
16-Jan-11	**48.9**	34	0	2,440					1 active	

17-Jan-11	46	34	T	1,990						
18-Jan-11	45	30	0	1,730						
19-Jan-11	43	32	T	1,520						
20-Jan-11	45	33.1	0	1,330	0					
21-Jan-11	46.9	33.1	0	1,210						
22-Jan-11	46	33.1	0.01	1,130						
23-Jan-11	50	30	0	1,040	1 inactive					likely spawned Jan 12-16
24-Jan-11	48.9	30	0	984						
25-Jan-11	51.1	32	0	990						
26-Jan-11	55	30.9	0	944						
27-Jan-11	51.1	30.9	0	888						
28-Jan-11	43	30.9	0	863						
29-Jan-11	**44.1**	39.9	0.18	**1,430**						**0.85" rain at Birdsview**
30-Jan-11	**45**	36	**0.4**	**1,930**	0	0				**0.65" rain at Birdsview**
31-Jan-11	**45**	36	**0.34**	**1,540**						**0.25" rain at Birdsview**
1-Feb-11	41	32	0.01	1,230						
2-Feb-11	42.1	32	0.03	1,050				1 inactive	2 inactive	likely spawned Jan 30-Feb 1
3-Feb-11	41	28.9	0	941				0		
4-Feb-11	39	28	0	846						
5-Feb-11	39	19.9	0	744						
6-Feb-11	32	18	0	668						
7-Feb-11	34	17.1	0	702						
8-Feb-11	36	21	0	650						
9-Feb-11	39	21	0.02	664						
10-Feb-11	36	30	0.14	756						
11-Feb-11	41	33.1	**0.62**	**1,590**		0			0	
12-Feb-11	46	36	**0.82**	**2,460**						
13-Feb-11	51.1	37	0.31	**2,070**						
14-Feb-11	50	37.9	0.22	1,850						
15-Feb-11	46	37	0.21	2,270						**1.35" rain Birdsview**
16-Feb-11	**46.9**	37	**0.67**	**2,650**	0	0			0	
17-Feb-11	**42.1**	36	**0.44**	**2,370**						**0.65" rain Birdsview**
18-Feb-11	**42.1**	36	**0.42**	**2,400**						**1.5" rain Birdsview but snow at upper elevations**
19-Feb-11	**43**	35.1	**0.95**	**2,380**	0	0			1 active	**0.9" rain Birdsview**
20-Feb-11	43	33.1	0.47	1,820	2 inactive	0			0	2 inactive redds upper Savage less than week old; active sea-run cutthroat spawning at Dry
21-Feb-11	48	33.1	0.41	1,610						
22-Feb-11	43	28.9	0	1,360						
23-Feb-11	35.1	30.9	0.9	1,290						
24-Feb-11	34	30.9	0.82	1,410						
25-Feb-11	34	32	0.64	1,880						
26-Feb-11	44.1	33.1	0	1,810						
27-Feb-11	53.1	34	0	1,740						
28-Feb-11	48.9	35.1	0.18	1,710						
1-Mar-11	52	37	T	1,600						**from Feb 22-28 cold & snow & creeks too low for entry**
2-Mar-11	39	30.9	0.34	2,400						**2.0" rain Birdsview**
3-Mar-11	37	32	**1.45**	**6,500**						**1.05" rain Birdsview**
4-Mar-11	41	36	**1.4**	**6,900**						
5-Mar-11	41	36	**1**	**9,970**						
6-Mar-11	50	39	**0.83**	**13,400**						
7-Mar-11	45	41	**1.1**	**9,570**	0	0				creeks running high too high to survey well
8-Mar-11	57	37	0	**4,870**						
9-Mar-11	45	37	**1.72**	**12,600**						
10-Mar-11	**52**	42.1	0.11	**6,720**						thaw & rains began Mar 1[-2] with high bankfull flows thereafter with no survey conditions
11-Mar-11	**52**	39.9	0	**4,330**						
12-Mar-11	**57.9**	34	0	3,240	0				1 active 1 inactive	possibly another active redd at Dry but it was not counted due to the 2 fish on the one known active redd having dropped downstream as well
13-Mar-11	62.1	32	0	2,690	1 inactive	0	0			Savage redd made past 2 days just above Skagit entry; first O'Toole survey since Nov

14-Mar-11	60.1	37	0.35	**4,440**						
15-Mar-11	55.9	41	0.3	**3,540**	1 inactive					redd made within few days
16-Mar-11	50	41	**1.37**	**10,800**						
17-Mar-11	41	37	**0.78**	**5,630**						
18-Mar-11	46	34	0.06	3,500						
19-Mar-11	48.9	34	0.16	3,820	0				0	
20-Mar-11	43	36	**0.43**	3,550						
21-Mar-11	43	30.9	0.05	2,820		0			0	
22-Mar-11	52	30.9	0	**1,890**						**NF Stillaguamish landslide makes gage unreliable for a week or so**
23-Mar-11	44.1	32	0.2	1,080				0	0	Finney too turbid to survey
24-Mar-11	**54**	36	T	1,960						
25-Mar-11	**63**	39	T	1,980						**0.425" rain Birdsview**
26-Mar-11	**50**	41	0.27	2,650						**0.425" rain Birdsview**
27-Mar-11	**55**	41	0.15	2,580				1 active		barely enough visibility to survey
28-Mar-11	55	42.1	0.05	2,550	0	0				
29-Mar-11	45	42.1	**0.88**	**4,280**	0					**1.0" rain Birdsview**
30-Mar-11	45	41	**0.75**	**4,970**	0	0			0	**1.45" rain Birdsview overnight**
31-Mar-11	50	36	0.33	3,520						
1-Apr-11	61	35.1	T	2,600						
2-Apr-11	62.1	35.1	0	2,080	0	0				
3-Apr-11	60.1	37	0	1,840						
4-Apr-11	54	39	0.2	1,890						
5-Apr-11	55.9	41	0.06	2,000						**0.425" rain Birdsview**
6-Apr-11	48.9	43	**0.46**	**3,220**						**0.425" rain Birdsview**
7-Apr-11	**59**	43	0.07	**2,480**			1 inactive			1-2 wks old or more, l kely Mar 21-22 or Mar 31-Apr 1
8-Apr-11	**69.1**	45	0	**2,610**						
9-Apr-11	**53.1**	37.9	**0.6**	**3,570**						
10-Apr-11	**57.9**	36	T	2,420						
11-Apr-11	**60.1**	37	0	2,020						
12-Apr-11	**55**	41	0.01	1,820						
13-Apr-11	**63**	37	0	1,680	0	0				
14-Apr-11	69.1	37	0	1,590				8 inactive		1 redd a month old; 2 redds ~Mar 31-Apr 1; 2 redds 3-4 wks old; 1 redd 2-3 wks old; 1 redd 1-wk old; 1 redd 2-3 days old;
15-Apr-11	68	39	0.01	1,590						
16-Apr-11	55	44.1	0.22	2,240						
17-Apr-11	48	44.1	**0.61**	**5,340**						
18-Apr-11	50	42.1	**0.61**	**5,380**	0	0				
19-Apr-11	54	37.9	0.01	3,180	0					
20-Apr-11	53.1	39	**0.6**	**4,770**						
21-Apr-11	57	39.9	T	3,200						
22-Apr-11	**64**	44.1	**0.49**	3,190			1 inactive			~Mar 21-25; first sighted Apr 7 & estimated 1-2 wks old
23-Apr-11	55.9	41	0.17	3,190					0	
24-Apr-11	**57.9**	41	**0.96**	**4,630**						
25-Apr-11	52	39.9	0.32	3,780						
26-Apr-11	**59**	37.9	0	2,890						
27-Apr-11	57.9	39	0.29	2,760						
28-Apr-11	46.9	39.9	**0.88**	2,780						
29-Apr-11	**59**	39.9	T	2,350						
30-Apr-11	**73.9**	44.1	0	2,220		2 inactive				1 redd 2 wks old; 1 redd 3-7 days old
1-May-14	**82.9**	45	0	2,470						
2-May-14	**84.9**	48	0	2,800	0				1 inactive	redd 3-7 days old
3-May-14	**73**	46.9	0.17	3,130						
4-May-14	52	46	**0.61**	**5,370**						
5-May-14	48.9	46	**0.94**	**7,330**						
6-May-14	**57**	46	0.08	4,060	0	0		0	0	Finney too turbid; other creeks too high the previous 2 days
7-May-14	60.1	45	0.05	3,070			1 inactive			1-2 days old
8-May-14	66.9	45	0	2,700						
9-May-14	63	45	**1.22**	**7,010**						
10-May-14	50	44.1	**0.39**	**5,100**						

11-May-14	55	45	0.02	3,480		0	0			
12-May-14	**66.9**	46.9	0.01	2,890					1 active 4 inactive	active redd determined when redd found May 14th; others made within 24-36 hours
13-May-14	**78.1**	46.9	0	2,660						
14-May-14	**80.1**	52	0	2,670				7 inactive	0	6 Finney redds 2-4 days old; 1 redd 1-2 wks old
15-May-14	**82.9**	52	0	2,790		0	0			
16-May-14	**84**	52	0	2,670				2-inactive	0	both redds ~2 wks old
17-May-14	**70**	52	0	2,310						
18-May-14	**66**	48	0	2,090						
19-May-14	**64.9**	48	0	2,490						
20-May-14	**69.1**	51.1	0	2,000						
21-May-14	**69.1**	45	0	1,810				1 inactive	0	within the week
22-May-14	68	46	0	1,740			1 inactive			within 1-3 days
23-May-14	77	51.1	0	2,100						
24-May-14	64.9	51.1	0.19	2,510						
25-May-14	66.9	48.9	T	1,870						
26-May-14	55.9	48.9	0.21	2,060						
27-May-14	61	48	0.15	1,970						
28-May-14	66	48	0	1,630						**0.525" rain at Birdsview**
29-May-14	59	48	0.3	1,660						**0.375" rain at Birdsview**
30-May-14	60.1	46.9	0.05	1,540				0	0	
31-May-14	71.1	46	0	1,430						
1-Jun-14	73.9	46	0	1,420						
2-Jun-14	72	46	0	1,400						
3-Jun-14	75	48	0	1,420						
4-Jun-14	68	48.9	0	1,330						
5-Jun-14	69.1	46.9	0	1,240						
6-Jun-14	72	46	0	1,150						
7-Jun-14	77	46	0	1,100						
8-Jun-14	77	46	0	1,060						
9-Jun-14	75	51.1	0	1,070						
10-Jun-14	72	48	0	1,030						
11-Jun-14	64	46	T	922						
12-Jun-14	73.9	46	0	**910**						**0.725" rain at Birdsview**
13-Jun-14	69.1	52	0.46	**1,320**						
14-Jun-14	55	51.1	0.23	1,250						
15-Jun-14	55.9	50	0.04	1,070						
16-Jun-14	63	48.9	0.05	1,300			1 inactive			~2 wks old
Survey total					**24**	**20**	**8**	**10**	**21**	

Appendix G.

Table 1.
Mean Air Temperature per Month in Fahrenheit at Concrete, WA from 2010 to 2014

Year	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
2010	41.44	42.89	45.45	48.43	52.63	58.47	64.77	64.76	60.1	53.34	40.23	38.85
2011	37.48	36.59	41.61	43.95	51.19	57.73	60.47	63.9	61.53	50.98	40.62	37.5
2012	36.18	40.33	39.9	49.72	53.34	55.37	63.03	65.9	61.05	50.89	43.88	38.15
2013	35.82	39.91	43.82	48.13	55.84	60.1	65.32	66.08	61.92	50.69	42.88	35.05
2014	40.27	36.32	43.19	48.95	57.32	59.58	65.6	67.73	....	....	....	....
mean	**38.24**	**39.21**	**42.79**	**47.84**	**54.06**	**58.25**	**63.84**	**65.67**	**61.15**	**51.48**	**41.90**	**37.39**

Table 2.
Mean Precipitation per Month in Inches at Concrete, WA from 2010 to 2014

Year	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
2010	9.55	4.68	5.73	5.83	5.85	3.26	0.2	0.58	7.38	4.74	9.8	11.31
2011	14.09	6.11	11.73	7.19	3.73	1.46	1.91	0.21	2.18	5.5	12.59	4.33
2012	12	9.38	11.62	5.2	4.14	4.22	2.18	0.01	0.33	9.88	11.25	12.01
2013	9.27	5.2	7.65	7.21	3.41	3.33	0.06	2.25	9.08	3.08	8.65	6.85
2014	10.7	8.28	14.08	6.57	4.39	2.54	2.13	2.04	....	....	....	....
Mean	**11.12**	**6.73**	**10.16**	**6.40**	**4.30**	**2.96**	**1.30**	**1.02**	**4.74**	**5.80**	**10.57**	**8.63**

Table 3.
Mean Streamflow per Month in cfs at the North Fork Stillaguamish River from 2010 to 2014

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2010	2,751	1,333	1,417	1,807	1,747	1,668	500	275	1147	1,786	3,189	4,962
2011	4,768	1,733	2,751	2,609	2,453	2,096	1194	542	416	1,097	2,843	1,931
2012	2,762	2,649	2,391	2,949	2,686	2,059	1178	427	275	1,825	3,738	2,531
2013	2,228	1,819	2,952	3,188	2,409	1,361	634	354	1019	1040	2157	1470
2014	2602	1533	4850	2844	2884	1135	692	364	....	....	....	....
Mean	**3,022**	**1,813**	**2,872**	**2,679**	**2,436**	**1,664**	**839**	**392**	**714**	**1,437**	**2,982**	**2,724**

May 4, 2015

Steve Leider
NMFS Sustainable Fisheries Division, West Coast Region
510 Desmond Drive SE, Suite 103
Lacey, WA 98503

Sent via email to: ***steve.leider@noaa.gov***

Re: Comments on WDFW's Early Winter Steelhead Hatchery Programs in Dungeness, Nooksack and Stillaguamish Rivers

Dear Mr. Leider:

We appreciate the opportunity to submit this letter as comment on NOAA's Draft Environmental Impact Statement regarding the Environmental Assessment on three early winter steelhead hatchery programs.

We believe there are some biological risks, economic impacts and timing issues with recovery planning that have been overlooked in this Environmental Assessment (EA). The following summarizes our key concerns.

No steelhead recovery plan in place yet.

It is hard to evaluate how these hatchery programs fit into the overall recovery strategy or the limits the hatchery programs will pose to recovery without the steelhead recovery plan completed. A better discussion of how the recovery plan will affect these programs, and how they will be adapted, is suggested if this analysis and the HGMPs are approved prior to the completion of the recovery plan.

Assessment of impacts to wild fish productivity on the accelerated loss of juveniles

When a hatchery fish spawns with a wild fish the resulting offspring have a much lower survival rate. While WDFW's introgression work estimates how much hatchery/wild pairing has taken place, there is no discussion of the projected effects on these populations by taking individual wild adults (and their offspring) out of the productivity equation resulting from spawning with hatchery origin adults. There

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should be an analysis of this resulting loss of productivity – especially in very small populations.

Cumulative Effects

It is critical that your review evaluates the cumulative effect of each and all of these programs and it is questionable that you have done that sufficiently in this EA.

Wild Steelhead Management Zones

NOAA has made an effort in the Lower Columbia to ensure that there are significant populations of wild steelhead that are managed as wild fish zones to preserve high quality genetic stock. Identifying wild fish management zones is a critical and essential step in ensuring future fisheries that are self-sustaining. More information on how the wild fish management zones will be chosen and implemented – and how decisions on these programs will affect zoning would be helpful.

The risk of predation on juvenile fall Chinook, fall chum, pink, and sockeye salmon

Your premise is that because WDFW is "releasing steelhead when they are fully smolted, and, thus, actively migrating to marine waters (WDFW 2014a; WDFW 2014b; WDFW 2014c) …it would result in a low, negative effect on predation of natural-origin fall Chinook, fall chum, pink, and sockeye salmon."

While this may be true when discussing relatively healthy populations where low predation has a low negative effect, in critically small populations, it seems this predation can impact a large percentage of the wild population. Given the low numbers of some of the listed Chinook populations, Dungeness River's current wild spring Chinook (150); Nooksack Chinook (SF:53, NF:211), there should be a better explanation of release timing and overlap with these juvenile populations and the abundance of each in order to evaluate the negative impact.

As an example, in 2010 WDFW estimated approximately 30,000 juvenile spring Chinook were naturally produced in the Dungeness River. WDFW proposes to release 10,000 steelhead smolts from Dungeness Hatchery. If each of these smolts ate just one naturally produced Dungeness spring Chinook juvenile, 30% of the natural production would be lost. Without timing, space and abundance of juvenile data it is difficult to evaluate the effect on these critically low populations of listed Chinook.

Compliance of instream structures with NMFS's screening and fish passage criteria

There are a number of facilities that are either scheduled to be updated as funding is provided or meet the standard that was in place when they were built. Standards for fish passage and protection of juvenile fish from being trapped on hatchery intake screens have been update for a legitimate reason. The continued operation of a structure that doesn't meet current standards increases the risk to listed fish. Facilities

that have not met NMFS 2011 criteria should not be allowed to operate in waters with listed fish – until they meet those standards.

Economic Benefits

There is an over-estimate of the economic benefit of these three winter steelhead programs. First, it lumps summer and winter steelhead populations together and states these three programs "produce 27 percent of the total hatchery-origin winter and summer steelhead released in Puget Sound annually for the purposes of augmenting fisheries harvests". The reader really has no way to assess the economic benefit of each individual hatchery program release or of the winter programs. Not all steelhead programs have the same survival from smolt to adult and not all programs contribute to fishers' at the same rate. Lumping winter and summer releases as well as a 10,000 Dungeness juvenile release with a 50,000 juvenile release in Nooksack doesn't bring clarity to the economic benefit of these individual programs in relation to their cost/risk. Each of these programs should have data presented to estimate survival (SAR) and catch in their respective watersheds.

Steelhead hatchery programs are expensive. WDFW's report on the cost per adult fish produced to the fishery doesn't seem to be discussed, nor the cost of improving these facilities to meet environmental standards.

Cost to produce adult steelhead

As part of WDFW's 2009 Hatchery Performance Summary Tables, WDFW estimated the following Cost of Adult produced from on-station releases:

- **Dungeness and Hurd Creek:** 55k juvenile release; 644 adults produced; $84/fish (Includes Dungeness, Hurd, western straits plants)
- **Kendall Creek Hatchery:** 150k juvenile release; 403 adults produced; $286/fish
- **Whitehorse Ponds Hatchery:** 150k juvenile release; 1,018 adults; $92/adult

Determined by: 1. Pro-rating operating budget across all on-station production at the hatchery; then prorated by species; 2. Cost of mass marking added to pro-rated cost; 3. Dividing cost by number of adults produced. 4. Costs of CWT was NOT included;

We question the economic potential of the selected Chambers Creek hatchery stock for these programs. It was noted in the recent 2013 Skagit River steelhead evaluation report that Chambers Creek origin hatchery steelhead have negative survival rates even lower than wild steelhead during low productivity ocean conditions. This will result in even less contribution to fisheries resulting in an even poorer return on an invested dollar in hatchery production.

We recognize the state and tribal co-managers' interest in developing new fishing opportunities and are supportive of programs that are not expected to impair the productivity, life history diversity, genetic composition and spatial structure of wild steelhead populations. We also believe these programs should be cost effective for the public. Based on the information provided in this EA we are not fully convinced that

these risks can be sufficiently minimized and encourage additional analysis and planning.

Sincerely,

Guido Rahr
President
Wild Salmon Center

Sara LaBorde
Executive Vice President
Wild Salmon Center

May 3, 2015

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[redacted]
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Steve Leider, Rob Jones, & Tim Tynan
NMFS Sustainable Fisheries Division
EWSteelheadHatcheries.wcr@noaa.gov.
510 Desmond Dr., Suite 103
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RE: Early Winter Steelhead Hatchery Programs - Proposed Evaluation & Draft Environmental Assessment

Dear Mssrs. Leider, Jones, and Tynan:

Please find my comments to Early Winter Steelhead Hatchery Programs – Proposed Evaluation & Draft Environmental Assessment as follows.

Sincerely,
Bill McMillan

COMMENTS

Is an EA Sufficient for This Analysis?

This is at the crux of the matter that involve ESA listed species, and for which there has been evidence of considerable prior controversy regarding the proposed actions involved. This proposed set of EA actions follows what was a well stipulated court settlement agreement that Chambers Creek hatchery steelhead plants would be curtailed for two years, or until the Puget Sound Hatchery HGMP evaluations through the then identified EIS process (not an EA process) otherwise indicated that these steelhead plants did not further threaten ESA listed steelhead in the Puget Sound ESU/DPS. An EA is not a substitute for the rigor of analysis that goes into an EIS, and therefore the EA process is not appropriate and likely illegal given the former well publicized settlement agreement.

My initial comment is that NMFS needs to bring itself into both legal and scientific compliance with a return to an EIS process for the cumulative impacts of the Chambers Creek hatchery winter steelhead on listed Puget Sound steelhead. And secondly, that Skamania hatchery origin summer steelhead programs need to be similarly included in such an analysis.

Draft Environmental Assessment Alternatives:

Of the four main alternatives, **Alternative 1 (No Action Alternative)** is the alternative that correctly identifies the part Chambers Creek origin hatchery steelhead have played in the decline of ESA listed Puget Sound steelhead. I agree with this alternative as the best choice from which to anticipate recovery back toward a population that can sustainably provide necessary escapement to seed all available habitats and a harvest level tailored to their actual escapement needs for sustainable productivity.

Alternative 4 (Transition to Native Broodstock), inevitably will result even if **Alternative 1** were to be initially chosen, knowing the past history of steelhead management in Washington and its determined tie to hatcheries. **Alternative 4** would be my first alternative in its obvious advantages of eliminating Chambers Creek hatchery plants immediately and the cost savings of quickly shifting to a different hatchery program evaluation process. However, as the recent shift from an EIS to an EA demonstrates with the Chambers Creek process, there is no reason to trust that NOAA/NMFS will comply with a full EIS evaluation process for Puget Sound wild broodstock hatchery programs, but will also shift to the present watered-down EA process if WDFW and/or the Puget Sound Treaty Tribes (PSTT) say "boo." Credibility by all involved has been lost. As a result, I cannot consider **Alternative 4** as the obvious cost-saving and time-saving solution due to the present example of how NOAA/NMFS, WDFW, and PSTT have collaboratively chosen to ignore the most vigorous process of hatchery evaluation. There has been no example of trust by any of the above parties to merit this choice. This is not to say that a shift to wild broodstock hatchery programs is any more acceptable than the Chambers Creek hatchery program. It, in fact, has at least as many or more problems for wild steelhead recovery. But that is the purpose of an EIS, to ensure that a full evaluation and debate of such a shift occurs, and it is evident that a proposed shift to wild broodstock hatchery programs (in at least some watersheds) is going to be coming down the pipe.

Comments to the Draft EA Document:

Regarding: 1.3, Purpose and Need for the Proposed Action

NMFS lists three proposed needs of which the first two appear to be in considerable conflict as being used in this EA:

- Ensure the proposed hatchery programs comply with requirements of the ESA
- Meet NMFS's tribal treaty rights trust and fiduciary responsibilities

Presumably the driving criteria of the ESA are to halt an animal's progression toward extinction and to provide recovery toward a less threatened level (in the case of a "threatened" listing). Yet, hatchery fish have been universally included in the four Hs that negatively affect wild salmon and steelhead populations. During the Boldt Decision process from 1974 onward a conservation driver was included that limited the 50/50 harvest allocation between tribal and non-tribal fishers to that salmon/steelhead return that is above spawning escapement needs. At that time it was not yet established that

hatchery fish may actually result in harm to the perpetuation of the anadromous fish returns, but in the Definitions section of the 1974 Boldt Decision Document it does describe the need to use the most recent facts and data available to guide fish production potential that included artificial production and the potential for interspecific competition and the resulting prospects for improvement of anadromous fish production, to perpetuate the runs of anadromous fish at least at their current level (Appendix A provides some of the basic 1974 Boldt Decision rulings and considerations – one quotation below):

"To preserve and maintain the resource: Upon a full consideration of (a) the history of State anadromous fish management, (b) the level of catch within the Western District of Washington in recent years, (c) the quality of freshwater and artificial production environments, (d) the most recent facts and data concerning anadromous fish production potential, (e) the potential for interspecific competition, and (f) the prospects for improvement of anadromous fish production, to perpetuate the runs of anadromous fish at least at their current level."

Presumably this number of fish to be maintained for both escapement needs and harvest was that of the 1960s to early 1970s when the Boldt case circumstances were being particularly considered. Although spawning escapements were not known at that time, harvest was. How well harvest has been provided by hatchery programs since then is particularly pertinent. More importantly, from the standpoint of the ESA, Puget Sound steelhead have been listed as Threatened due to their great decline since the Boldt Case and science has increasingly identified the part that hatchery steelhead have played in loss of steelhead productivity (Chilcote et al. 2011; and Seamons et al. 2012).

The Harvest Record History with that of Chambers Creek Plants

Whether hatchery steelhead programs have added to historical harvest formerly dominated by wild fish production prior to the modern hatchery steelhead program (dating to adult returns in 1962 by Royal 1972), or whether harvest has diminished with the advent of the modern hatchery program in Puget Sound streams over time, can be determined from records compiled by Washington Department of Game (WDG) in the aftermath of the Boldt Case Decision when combined with historic and more recent WDFW data since then (Taylor 1979; WDG 1948-1972; WDG 1948-1978); WDG 1956; WDG 1957; Scott and Gill 2006; WDFW 1995-2013 online sport catch reports; WDFW 2002-2013 online hatchery plants; and the 2014 Dungeness, Kendall Creek, and Whitehorse Hatchery HGMP documents from WDFW). The earliest of these compiled data, provided to me by WDFW at my request in 2006, provided steelhead sport harvest, hatchery smolt plants and tribal steelhead harvest for the Boldt Case streams from the earliest record keeping available up to 1978. Sport harvest had been adjusted to reflect what it was considered to be as related to implementation of the Boldt Case rulings.

Figures 1-3 provide the combined sport and tribal harvests of both wild and hatchery winter steelhead for the complete period of available historic records as compared to the winter steelhead hatchery smolt plants for the Nooksack, Stillaguamish, and Dungeness rivers. In all three cases it is very clear that at the minimum hatchery steelhead plants

Figure 1.

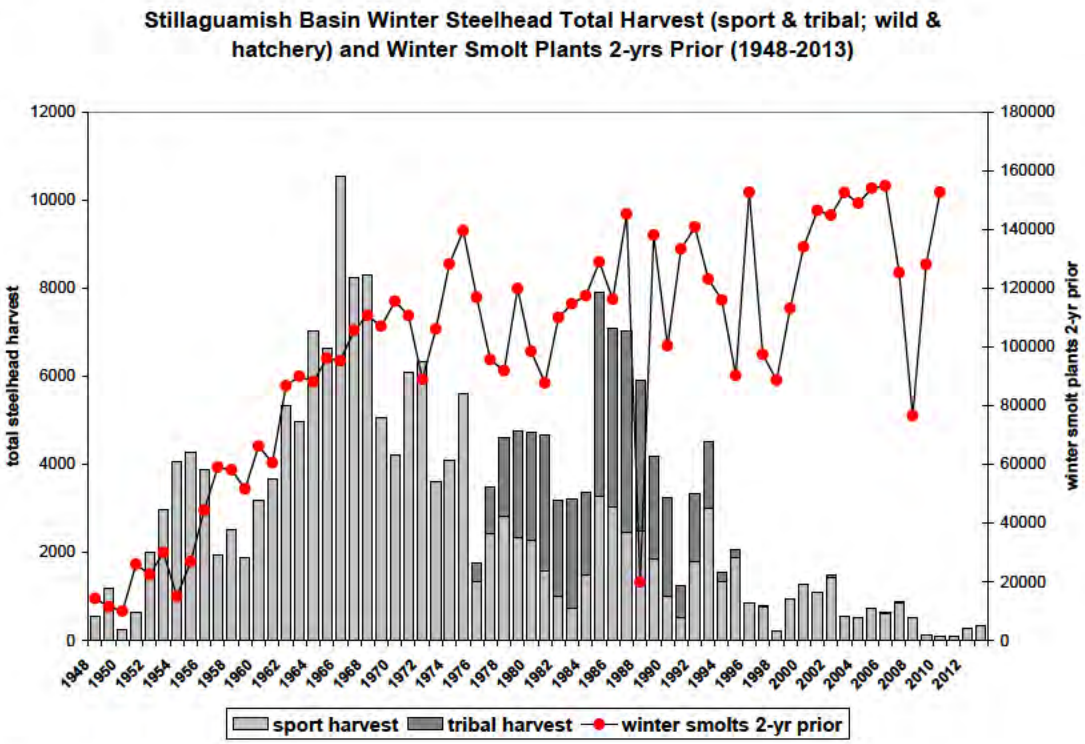


Figure 2.

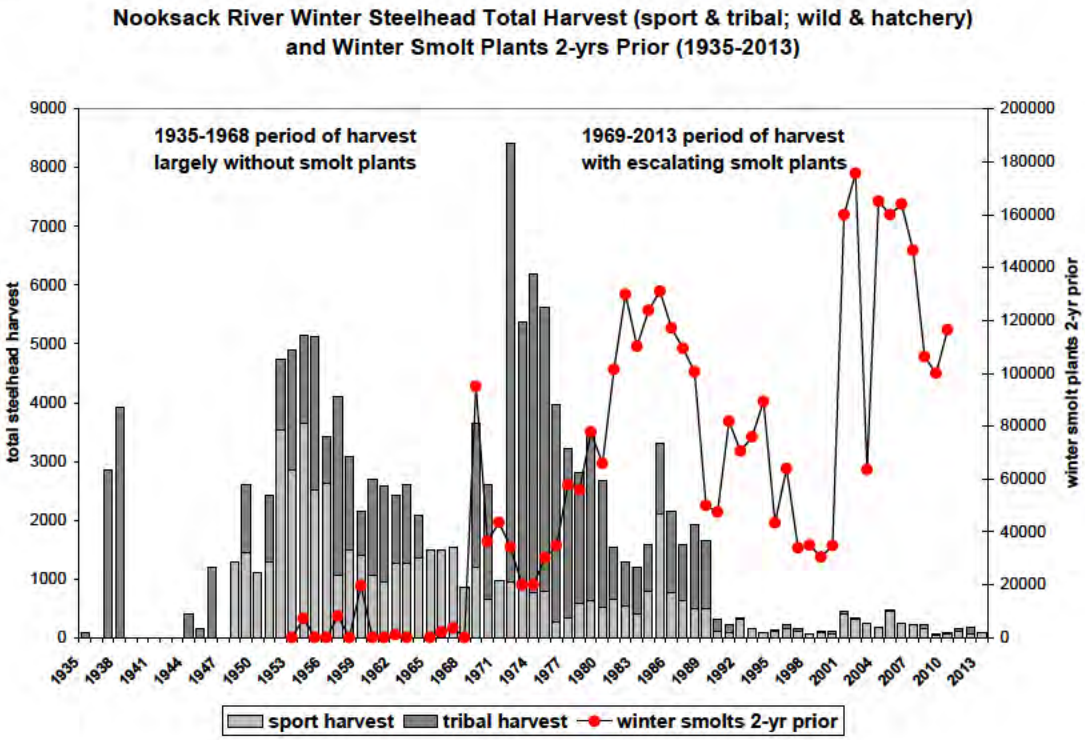
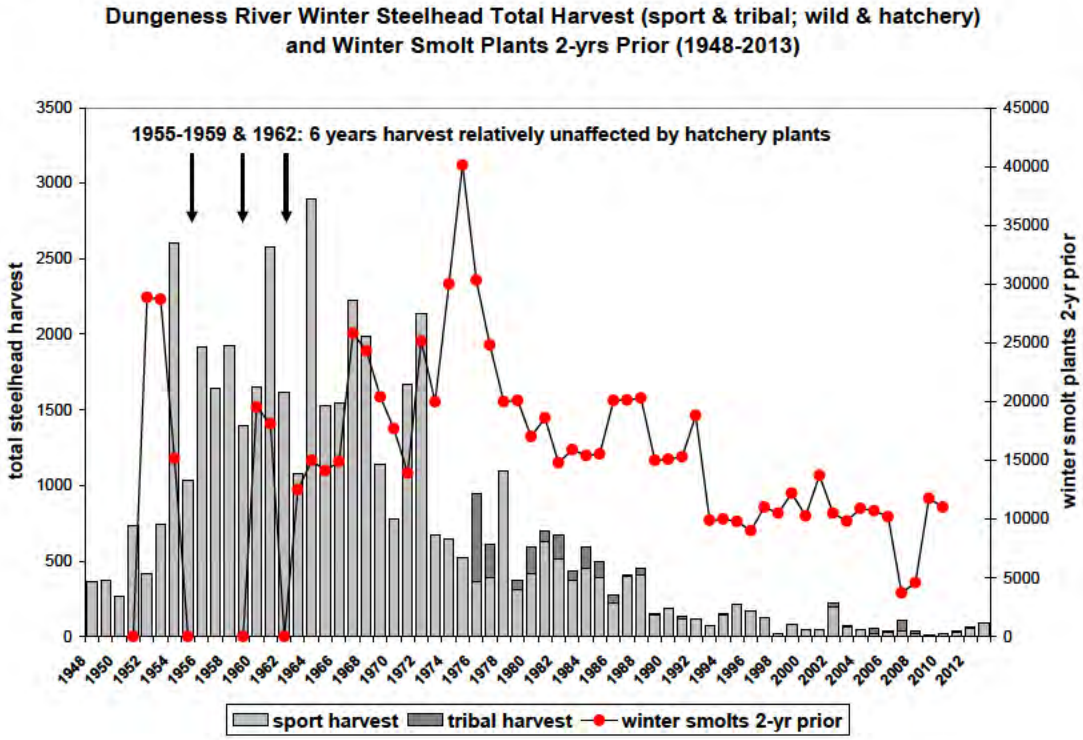


Figure 3.



have not resulted in perpetuation of winter steelhead harvest as one of the basic criteria of the Boldt Decision's conservation and harvest management obligations, and in fact, it might better be indicated that steelhead harvest has collapsed coinciding with the modern winter steelhead hatchery history from 1962 returns onward.

The resulting pattern of hatchery steelhead bringing back increasingly less harvest reflects the history of Chambers Creek origin hatchery steelhead at their original Chambers Creek location at Chambers Creek and South Tacoma Hatcheries where this population went entirely extinct in 1997 (Appendix B). This continuous decline in productivity in what had been the oldest hatchery steelhead population in Washington, that dates to hatchery use since the 1920s (but data limited to 1953 onward), is evident in the graphs in Appendix B (Cooper and Johnson 1992) and eventual population extinction (Eltrich 2007). It is apparent that this highly domesticated stock of steelhead had lost eventual ability to survive seaward migration and back again, let alone the ability to provide harvest (Chambers Creek closed to steelhead harvest). Given Figures 1-3, and the Chambers Creek example in Appendix B, it can only be concluded that steelhead management that continues to advocate use of Chambers Creek steelhead plants as a means to fulfill its long ago outdated promise of perpetuating steelhead harvest is an action based on what can only be termed insanity – one definition of which is irrationality; or from the legal dictionary: mental illness of such a severe nature that a person cannot distinguish fantasy from reality.
http://dictionary.law.com/Default.aspx?selected=979&bold=||||

(Regarding the conveyance of this eventually lethal trait of Chambers Creek steelhead to that of the wild populations with which it cohabits in streams, it will be discussed later in these comments, along with the necessary high harvest rates required to try and minimize their escapement into the spawning grounds of wild steelhead and subsequent loss of the early-return life history of wild steelhead.)

Escapement data do not go back beyond 1985 for the Stillaguamish, only spottily available to 1987 for the Dungeness, and not beyond the very recent history of 2004 for the little-monitored Nooksack escapement limited to 5 years total of escapement data (Scott and Gill 2006; and the 2014 Dungeness, Kendall, and Whitehorse Hatchery HGMPs).

In the case of the Nooksack, it is particularly clear that sport and tribal harvest have been in violation of the driving management criteria of the Boldt Decision from which harvest allocation was to be based on the conservation necessity of determining escapement. There is no evidence of what the escapement has been compared to the harvest, with no way to evaluate what has happened to the returns except via the harvest records. It is but little better for the Dungeness, and even at the Stillaguamish escapement data did not begin until over 10 years after the Boldt Decision (Scott and Gill 2006).

In the case of the Skagit River, where comparative data have been analyzed recently (Pflug et al. 2013; and McMillan 2012), the wild steelhead escapement trend has largely reflected the total harvest trend (McMillan 2012), as would have to be the case unless gross mismanagement had occurred prior to the Boldt Decision through great overharvest. From this it can be largely deduced that escapement trends, if available back to the late 1950s when most returning steelhead were wild, would largely track the historic harvest trends.

Smolt Plants Outweigh Adult Chambers Creek Steelhead Contribution to Harvest

In the examination of the HGMPs for each of the hatcheries included in this EA, it became evident that the weight of the smolts being planted is greater than the contribution of their adult return to harvest. To test this, the given weight of the smolts per pound was divided into the number of smolts planted at each hatchery to determine the total weight of smolts planted. Attempts were made through contacts by Jamie Glasgow of Wild Fish Conservancy to WDFW personnel to determine the average weight of adult Chambers Creek origin steelhead on return, but no response was provided (at least in the time frame required for this EA response). Alternatively, from 1999 through 2014 I personally caught and measured 24 Chambers Creek origin hatchery fish (from Marblemount Hatchery) in the Skagit River. Meigs and Pautzke (1941) provide a curve for the lengths (in inches) to weights (in pounds) of steelhead from several hundred winter-run steelhead sampled at the Green River of Puget Sound at that time. I used this curve to convert the known lengths of the 24 Chambers Creek steelhead caught to pounds with resulting averages of 26.265 inches in length and 6.9 pounds in weight (see Appendix C). This assumes that the wild winter steelhead of a nearby Puget Sound

stream in 1941 represent similar length and weight patterns as Chambers Creek origin hatchery steelhead. A subsequent average weight of 7 pounds was used to represent the weight of each Chambers Creek origin winter steelhead harvested as described below in computations for each of the three rivers related to this EA.

In the case of the Dungeness River, the hatchery steelhead plants have resulted in an average annual tribal harvest since 2001 of only 14 hatchery steelhead, and an annual sport harvest of 49 hatchery steelhead. The smolts released average 5.4/lb with an average of 9,893 smolts released since 2001, or 1,832 lbs of smolts planted. The subsequent annual hatchery adult tribal harvest is 98 lbs, and the sport harvest is 343 lbs with a combined harvest of only 441 lbs if the average returning hatchery steelhead is about 7 lbs (no data provided, but see Appendix C). In other words, the smolts planted outweigh the harvested adults by 4.2 times. It is quite clear that those who want harvest would better benefit from killing and processing the smolts going out rather than depend on harvest of returning adults with their cumulative loss of weight on return.

The Kendall Hatchery results are even worse, with an average annual hatchery steelhead plant of 106,233 since 2001, with 19,315 lbs of smolts planted at an average of 5.5/ lb. The subsequent annual tribal harvest has been an average of 31 hatchery steelhead and an average sport harvest of 195 hatchery steelhead annually for a total of 1,582 pounds if each adult averages 7 lbs. The smolts planted outweigh the adult harvest by 12 times. Again, those who want harvest would better benefit doing so with the smolts rather than await the great loss of weight represented in the adult return.

The Whitehorse Hatchery results are between the two with an average annual hatchery steelhead plant of 134,750 winter smolts since 2001 at 6 /lb, or 22,458 lbs planted. The subsequent annual tribal harvest has averaged 12 hatchery steelhead and with 572 sport harvested for a total of 4,088 pounds if each averages 7 lbs. The smolts planted outweigh the adult harvest by 5.5 times. Again, those who want harvest would be better off by killing and processing the smolts rather than await the substantial loss of their cumulative weight on the adult return.

Given the above considerations, it is clear that there is an alternative that no one has discussed before that would provide greater weight of Chambers Creek origin fish by harvesting them in May as smolts rather than release them, provide easy 50/50 harvest allocation, and eliminate the impacts on wild steelhead and resident O. mykiss that otherwise result from mixed stock fishery impacts with loss of early-return life histories, residualism, precocious parr, predator attraction, and eventual genetic consequences related to overlapping spawning times. Chambers Creek steelhead are well adapted to hatchery pond confinement but not to migration and return through the filter of the wild environment. This is far and away the best economic and biological use of Chambers Creek steelhead – that of providing enclosed aquaculture with minimal ecological impacts beyond effluent from the hatcheries with some resultant levels of pollutants and potential disease transmission. Sound ludicrous? Not nearly as ludicrous as what presently occurs and which this EA process contrives to perpetuate. An EIS process would have to dig into this, along with the actual smolt-to-adult return ratios (SAR) that

reflect the inability of Chambers Creek origin hatchery steelhead to effectively return, with a declining trend over time clearly indicated from the Chambers Creek steelhead data at Chambers Creek from 1953 to 1991 (Appendix B, from Cooper and Johnson 1992).

Regarding: 3.3, Salmon and Steelhead; and 3.3.1, Genetic Risks

There has long been a fallacy in Washington that Chambers Creek origin steelhead with early run-timing and early-spawn-timing are isolated, or segregated from wild steelhead run-timing and spawn-timing. This has been disproven by several findings to determine this at Forks Creek in Washington at Willapa Bay, with substantial indication of hatchery/wild hybridization and resulting loss of productivity in the hybrids that subsequently become part of a mixed population of naturally spawning steelhead that includes hatchery, hybrid, and wild spawners. This has been despite the use of a weir to further attempt to prevent these spawning interactions to occur as a backup to the assumed segregation of the hatchery steelhead from wild steelhead due to early-spawning selection of the hatchery component (Seamons et al. 2012; Jones 2014; Naish et al. 2014).

It is of interest to follow the findings of the Forks Creek studies over time. What came to be considered in 2003 (McLean et al. 2003) came to be the conclusion in 2012 (Seamons et al. 2012) and subsequently further by Naish et al. 2014) as can be seen by the following quotations:

In 1996, 90% of the hatchery steelhead had returned by March, but fewer than half of the wild adults had returned by this time; the majority of the wild adults returned in May. In 1997, the hatchery fish again returned early and wild fish returned late. In the next generation, the patterns changed slightly, and there were more late-returning hatchery-assigned fish (especially for the progeny of BY1997). The blending of return times between the two groups, especially for the progeny of 1997, is consistent with the possibility of interbreeding and hybridization.

Because of the number of shared alleles, overlap in allele frequencies, and low FST value between the two populations, it is not possible in this analysis to determine if the overlap in return timing of the parental generation resulted in any hybrid offspring between hatchery and wild fish. However, in addition to the altered return timing of the offspring generation relative to the timing of pure parental forms, there is indirect genetic evidence for some hybridization. There were many more offspring than parents with likelihood ratios close to zero (26 vs. 8%). The ratios are negative for the hatchery population and positive for the wild population, and so would be close to zero for hybrids. Hybridization has been documented among native and non-native or wild and hatchery populations in a number of species (McGinnity et al. 1997; Crozier 2000; Hansen 2002), and may be occurring in Forks Creek steelhead as well.

Although currently the question of hybridization remains unanswered, future analysis of specific parentage may enable us to determine the extent of interbreeding between the two groups, and the survival rates and reproductive success of their hybrids. With the poor reproductive success of the hatchery fish, hybridization between the two

groups will likely have a negative effect on the wild population, and potentially decrease the reproductive success of the wild group. If the productivity of the hybrids is intermediate between that of the two groups, the wild population faces potential loss of unique locally adapted gene complexes, a severe reduction in abundance, or even extirpation unless the hatchery genotype is quickly culled from the population. The cessation of releases of hatchery fish after the first 2 years provides the wild population with the opportunity to resist introgression.

In conclusion, hatchery fish originating from a distant location and artificially selected for early return and spawn timing (and probably adapted to hatchery conditions) successfully reproduced in the wild. Although they produced offspring that survived to return to spawn themselves, the per-capita reproductive success of hatchery fish spawning in the wild was much less than that of the wild fish. The potential for hybridization between the two groups because of their overlap in timing may represent the most significant problem facing the wild steelhead population in Forks Creek. The hatchery group did not replace itself, and the survival rate and reproductive success of the hybrids are not yet known. Even with minimal differentiation at neutral loci, the difference in fitness between these two groups is significant.

Salmonid conservation depends on knowing the consequences of introductions and artificial propagation on native populations, and our project contributes to the emerging picture provided by similar studies...

The following Abstract from Seamons et al. 2012 describes the subsequent Forks Creek findings:

Two strategies have been proposed to avoid negative genetic effects of artificially propagated individuals on wild populations: (i) integration of wild and captive populations to minimize domestication selection and (ii) segregation of released individuals from the wild population to minimize interbreeding. We tested the efficacy of the strategy of segregation by divergent life history in a steelhead trout, Oncorhynchus mykiss, system, where hatchery fish were selected to spawn months earlier than the indigenous wild population. The proportion of wild ancestry smolts and adults declined by 10–20% over the three generations since the hatchery program began. Up to 80% of the naturally produced steelhead in any given year were hatchery/wild hybrids. Regression model selection analysis showed that the proportion of hatchery ancestry smolts was lower in years when stream discharge was high, suggesting a negative effect of flow on reproductive success of early-spawning hatchery fish. Furthermore, proportions of hybrid smolts and adults were higher in years when the number of naturally spawning hatchery-produced adults was higher. Divergent life history failed to prevent interbreeding when physical isolation was ineffective, an inadequacy that is likely to prevail in many other situations.

The following quotation from Naish et al. 2014 further relates to the Forks Creek findings:

The major findings of this study are that despite increasing population sizes, the effective size of the hatchery population was relatively small and that the maintenance of small

effective sizes had fitness consequences within a few generations. Our earlier study showed that the number of hatchery fish in the drainage is large compared with the wild population, and hybridization occurs between the two populations (Seamons et al. 2012). Therefore, it is possible that the effective size of the wild population will be reduced (Ryman & Laikre 1991), leading to inbreeding and inbreeding depression in weight, length and return date in the population as a whole.

Chambers Creek Hatchery Steelhead Straying to Wild Steelhead Spawning Areas

There is further evidence that the specified location of hatchery steelhead plants does not similarly determine their eventual destinations. This is due to the well identified mechanism of straying. It is a key factor of why a full EIS is the necessary means for examining the potential for hatchery impacts to wild ESA listed steelhead populations outside of the stream basin where the plants originated from. Although straying of hatchery steelhead was not well examined during the long-term wild steelhead studies at Snow Creek of northeastern Puget Sound, it was nevertheless partially documented in one published study as limited to the period of time of 1982-2000 (Seamons et al. 2007) and which was drawn from as part of the recent Skagit River steelhead study funded in part by NOAA (McMillan 2012).

From McMillan 2012, page 44 and Figures 4 and 5 below:

Although Snow Creek is useful as a stream that has had relatively little hatchery steelhead smolt stocking (hatchery winter-run steelhead smolts were stocked for three

Figure 4.

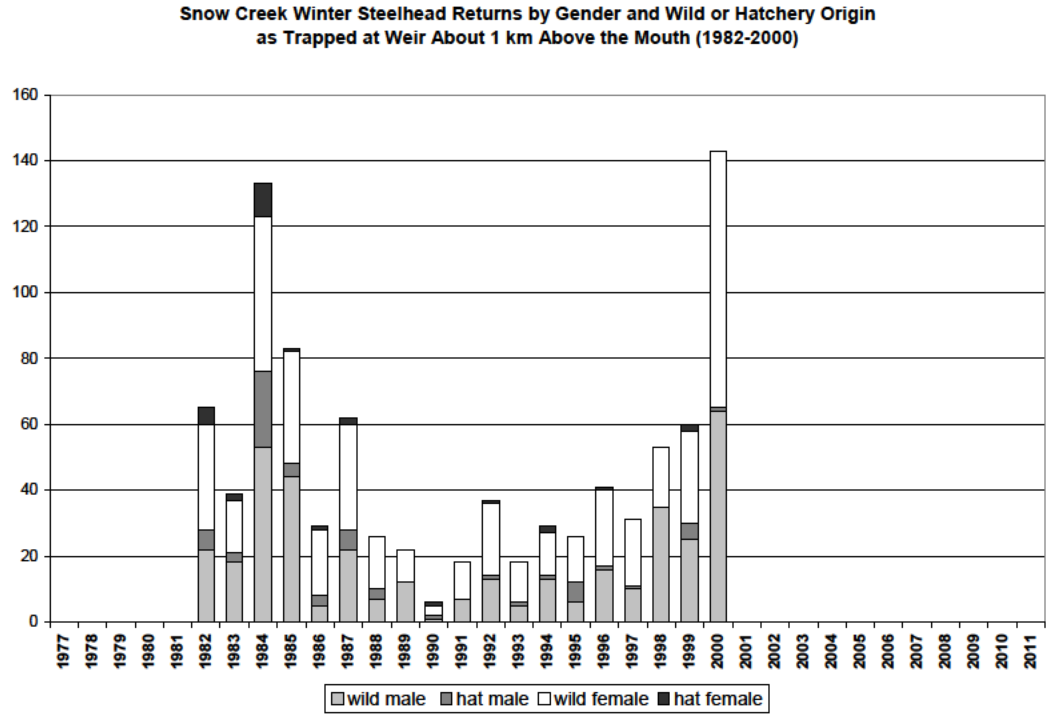
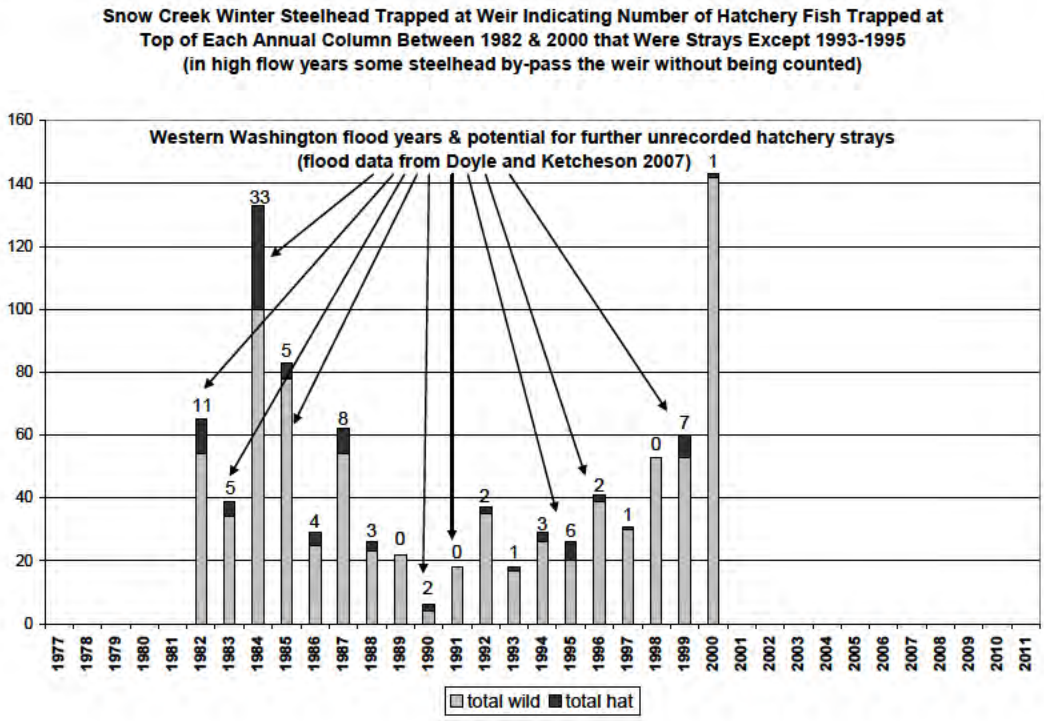


Figure 5.



years as part of a hatchery steelhead smolt study in the early 1990s [Tipping et al. 1995]), it nevertheless has sometimes had significant hatchery steelhead strays return as documented at the weir (Figures 37 and 38; and Seamons et al. 2007). Other hatchery strays not documented likely pass upstream in particularly high flow periods when the weir does not operate efficiently and not all hatchery strays that were handled may have always been counted (pers. comm. Todd Seamons of WDFW February 2, 2012 and July 23, 2012). Hatchery straying beyond a weir meant to exclude hatchery steelhead passage at the Forks Creek on the southern Washington Coast often failed to do so despite efforts to eliminate hatchery steelhead straying upstream (Seamons et al. 2012). During 1990, a particularly low return year at Snow Creek, 50% of the returning males were hatchery origin (only 2 male steelhead total handled at the weir) and of the total return handled at the weir that year 33% were hatchery origin (only 6 steelhead total handled at the weir). Although hatchery fish are typically excluded when caught at the weir, some have shown evidence of having partially or fully spawned that could potentially have occurred either below or above the weir depending on flow events (pers. comm. Todd Seamons, July 23, 2012). Snow Creek is at the south end of Discovery Bay and relatively isolated from other steelhead streams and would seemingly provide a geographic location that would minimize hatchery straying into it. It therefore likely represents a best case example for lack of hatchery steelhead straying into it, yet it occurs – more so with males than females and some years 30% or more males. Other streams typically do not have weirs to exclude hatchery steelhead passage. In the case of Snow Creek with minimal steelhead planting history as a best case example, it can be anticipated that Puget Sound streams with histories of hundreds of thousands of annual hatchery steelhead smolt plants have subsequent hatchery straying to natural spawning

grounds that are greater than documented at Snow Creek and which can be highly variable year to year but persistent over the entire time of hatchery stocking history.

Spawning Surveys and Evidence of Within-Basin Hatchery Straying

Evidence of the more prevalent straying of Chambers Creek origin hatchery steelhead to wild steelhead spawning grounds is that of within-basin straying where the hatchery plants have occurred. WDFW long ago perpetuated a policy myth that Chambers Creek origin hatchery steelhead programs are isolated, or segregated from wild steelhead in both return time and spawning time. Myths can only be perpetuated by lack of harvest evaluation in the case of steelhead run-timing, and in the case of spawn timing it depends on limiting spawning surveys to the time period that begins with the selected mythology.

A basic Skagit River steelhead management assumption by Washington Department of Fish and Wildlife (WDFW) has been (WDFW 2004):

Page 118: "*Wild origin winter steelhead have been defined as those fish that spawn after March 15...* (and) *steelhead of hatchery origin that spawn in the wild are defined as those fish spawning before March 15, for management purposes on the Skagit (Woodin et al. 1984)."*

As a result, WDFW steelhead spawning surveys in the Skagit basin have commonly been initiated about March 15th in the assumption that wild steelhead do not spawn prior to that date. In the Skagit basin it was indicated in the same WDFW document:

Page 141: *"... introgression between hatchery and wild fish ... is believed to be low as there is currently substantial temporal separation of hatchery and wild spawn timings, and spawning overlap is believed to be less than 1% (C. Kraemer, WDFW, pers. comm., 12/12/03)."*

Page 142: *"The section of the Skagit River that has been the most heavily spawned by hatchery-origin adults is the area upstream of Grandy Creek between the Cascade and the Sauk rivers..."*

However, the above management assumptions have been largely made with an absence of spawning surveys that could actually document how much hatchery and wild spawning occurs in the Skagit basin prior to March 15th, and where it occurs. Oregon has developed a more thorough ground-truthed approach for monitoring steelhead of its Coastal streams (from Susac and Jacobs 1999):

Page 2: *"The percentage of hatchery origin steelhead spawning naturally in the wild poses a great deal of concern to fisheries managers. The Oregon Wild Fish Management Policy (OAR 635-07-525) sets guidelines as to the percentage of stray hatchery fish permitted to spawn naturally in individual basins and subbasins. It is important for fisheries managers to know the percentage of hatchery strays spawning naturally in the wild. Currently, all of the hatchery origin steelhead released in Oregon and destined to*

return as adults in 1998 are marked with an adipose fin-clip. We have started to evaluate the feasibility of using visual detection of marked and unmarked adults on the spawning beds to determine hatchery:wild ratios."

Page 2: *" ... 1) steelhead spend only a short time on spawning beds, 2) fish not actively spawning are elusive, and 3) hard to count and steelhead do not necessarily die after spawning. In addition to difficulties associated with their behavior in spawning streams, the extensive temporal and spatial spawning patterns exhibited by coastal winter steelhead stocks create challenging survey conditions. The spawning season is generally quite protracted, lasting up to 6 months..."*

As a result there are no assumptions about hatchery and wild steelhead spawning that exclude any part of the potential spawning season as monitored in spawning surveys in Oregon:

Page 10: *"Surveys were conducted from mid January to mid May.*

WDFW's isolated/segregated hatchery steelhead mythology ignores the small stream origin of Chambers Creek hatchery steelhead, and that it may, in fact, still represent significant overlapping characteristics such as return and spawning times that belie the figure by Scott and Gill 2008 as shown in the EA in section 3.3.1 (page 28) in its admittedly "schematic" portrayal of minimal opportunity for Chambers Creek origin steelhead to overlap with wild steelhead spawning. It is indeed schematic in that it is not based on any actual spawning surveys in Western Washington streams that have occurred in the period prior to about mid-March that could document what actual hatchery/wild spawning interactions do occur. It further does not represent the outcome at Forks Creek in the steelhead studies there.

On becoming a resident of the Mid Skagit basin in 1998, it became of increasing interest what salmonid spawning was occurring at a number of local tributary streams. With a history of doing volunteer spawning surveys as a hobby biologist from 1979 to 1996 on Lower Columbia River streams, and professionally from 1997 to 1998 in the Snohomish basin and from 2000 to 2006 in the urban creeks of King County (the results of which first documented the actual level of coho prespawning mortality in Seattle/Bellevue urban creeks after WDFW surveys failed to do so and subsequently led to collaborative and confirming studies by NOAA), the Mid Skagit tributary streams provided nearby interest due to differences in their hydrologic regimes, stream channel characteristics, and directional aspects to the sun. On retirement at the end of 2006 as a professional field biologist for a non-profit fish conservation organization, I had time to consider surveying streams again in the freedom of volunteerism as a hobby biologist – or what some consider today as citizen science.

A recent report on the five years of my independent spawning surveys at five tributary creeks of the Mid Skagit River basin was done for the specific purpose of filling in this gap in actual field work that has occurred to determine what the level of hatchery and wild steelhead spawning is prior to mid-March (McMillan 2015a; and 2015b). This

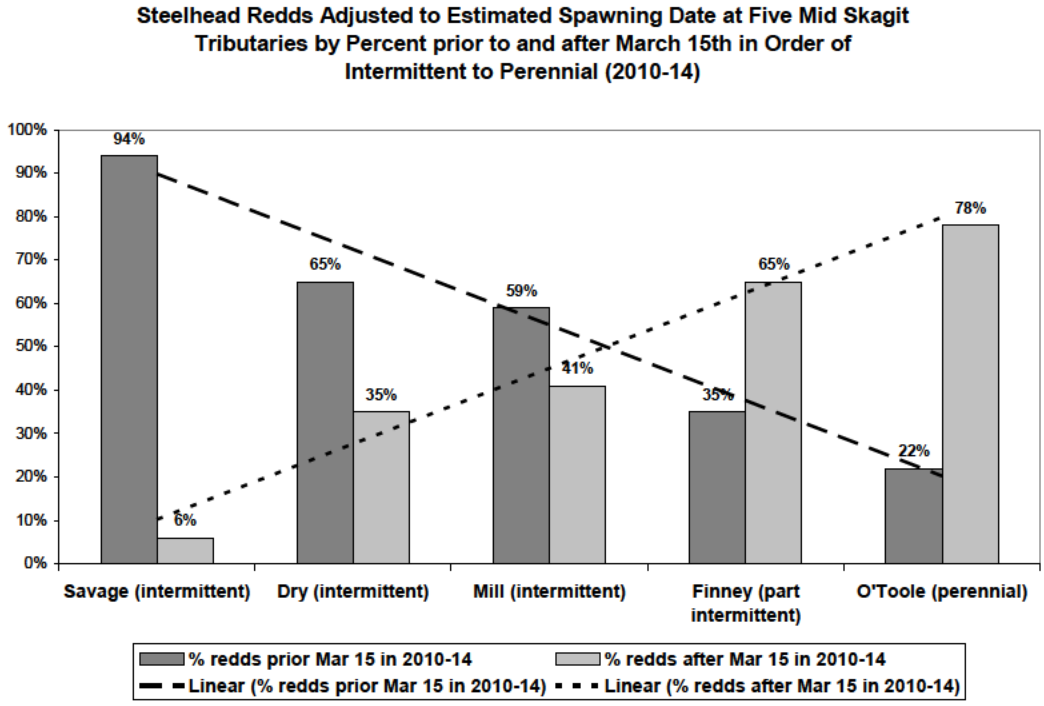
report was reviewed by George Pess of NOAA's Northwest Fishery Science Center with his suggestions included as far as the review went in the time frame he had to do so, but included the Introduction, Methods, and Results sections as the heart of the matter in the full draft report, and a review of the entire Summary that included some of the Discussion considerations. The findings in brief were as follows:

- 104 steelhead redds were found in the 5 year surveys
- Earliest redd was January 16th; latest redd June 6th
- 49% of the redds as found were prior to March 15th
- 53% of the redds were prior to March 15th if adjusted to spawn date
- 7 active redds with 18 spawning participants were observed
- 40% of the steelhead spawning mix observed was hatchery
- 60% of the steelhead spawning mix observed was wild
- 33% of spawning mix was hatchery if wild resident *O.mykiss* included
- 67% of the steelhead spawning mix was hatchery prior to March 15th
- 50% of spawning mix was hatchery prior to March 15th if wild resident *O.mykiss* included
- Although no hatchery steelhead were observed after March 15th, 20% of the steelhead could not be identified after that date
- Hatchery steelhead were found to the maximum upstream anadromous extent of even the smallest tributaries.

Importantly, the spawning time of steelhead in the tributaries surveyed varied by specific tributary characteristics (Figure 6). This was particularly related to whether a tributary was intermittent (mostly early spawning), perennial (mostly late spawning), or mostly perennial except some important side channels (mostly late spawning but more early spawning than a totally perennial stream).

The primary reason for early spawning in intermittent streams became abundantly clear as a result of photographs sequencing the rapid progress of intermittent streams sections going dry between late June and early July: late spawning would result in high to complete mortality of eggs and alevins that did not have time to reach free swimming fry stage by late June with outmigration to perennial flows of larger perennial waters downstream. Despite this seeming limitation, the one Skagit tributary with the highest steelhead redds per kilometer was that of the smallest stream that went dry the earliest, an otherwise unnamed tributary named for purposes of identification in the surveys as Dry Creek. This seeming contradiction was long ago described by Fred Everest (1973) in which he found that the Rogue River was entirely dependent on small, intermittent tributary creeks for its high steelhead productivity, but that it required early spawning and early emergence as the steelhead adaptation necessary for this to occur. The fact is that intermittent tributaries occur in virtually every Washington stream basin and is not a phenomenon limited to Oregon or California, and which can be anticipated to become more common as a result of climate change and habitat uses that include agriculture and industrialized forestry practices in Puget Sound river basins, including the three evaluated

Figure 6.



in this EA. The Mid Skagit tributaries surveyed have characteristics that equally occur in the Stillaguamish, Nooksack, and Dungeness river basins.

An evaluation since then, as done in the continuing surveys of these tributaries in 2015, has included more detailed water temperature data taken. It has revealed that the streams with warmest mean temperature also correlate with earlier spawning and colder temperature with later spawning. The combination of intermittent/perennial flows and mean water temperatures are likely the two best determinants of steelhead spawning time in tributary creeks. To ignore this is to ignore the spawning ecology of steelhead in the wild and how hatchery interactions and hatchery harvest management fit together to make tributary streams more or less productive for wild steelhead.

Some conclusions drawn from this (and which would apply to every river basin in Puget Sound) have been:

- Early steelhead spawning is especially necessary in creeks that go intermittent in June and can cumulatively dominate the steelhead productivity of large river basins as found at Rogue River
- Every river basin has tributary creeks that are intermittent and intermittency can be anticipated to more frequently occur with northward expansion if climate trends continue as predicted
- Of the 5 Mid Skagit tributaries regularly surveyed, 3 are intermittent and 1 partly so.

Ultimate Importance of Tributary Creek Spawning

For historic comparison, three of the five Mid Skagit tributaries regularly surveyed in 2014 were also surveyed in 1978-1981. The steelhead redds/km found in 2014 were 35%-78% of that in the earlier time period (Table 1). Mid Skagit tributaries are now apparently much less productive for wild steelhead than was the case about 35 years ago. This may not necessarily be explained by habitat loss and/or ocean conditions alone. It may be at least as significantly related to loss of steelhead life histories (such as early run-timing and/or early spawning) that can no longer fill formerly productive and widespread habitat that is increasingly left depleted or vacated. At that earlier time, the smaller tributaries were found to support 65-80% of all steelhead spawning in the Skagit basin despite an average escapement estimate of 5,700 wild steelhead, over 63% less than the preliminary escapement estimate of over 9,000 in 2014 (Table 2). If tributaries were at former productivity levels, presumably the 2014 wild steelhead return would have been greater than it was. Identifying and resolving the present limitations for tributary steelhead productivity in the Skagit basin may lead to considerable wild steelhead recovery progress.

Table 1. Steelhead redds/km in three Mid Skagit tributaries in 1978-1981 compared to 2014

Stream	redds/km 1978-1981	redds/km 2014	present % of former spawning
Finney Ck	11.9	5.7	48%
Mill Ck	5.0-6.8	2.4	35-48%
O'Toole Ck	10.3-22.2	8.0	36-78%

Table 2. Skagit basin wild steelhead spawning escapements 1978-1981 and 2014

Year	Wild steelhead escapement	Reference
1978	7294	Phillips et al. 1981b
1979	3943	Phillips et al. 1981b
1980	6009	Phillips et al. 1981b
1981	5435	Phillips et al. 1981b
2014	over 9000, as preliminary estimate still to be finalized	per. comm. Brett Barkdull, WDFW, Nov. 6, 2014

The 67% of hatchery steelhead found spawning in Mid Skagit tributaries prior to March 15th was of particular concern that would be anticipated to be most problematic for wild *O. mykiss* populations (that include both anadromous and resident life histories) at tributaries typified by warmer winter flows and/or intermittent hydrology. Four of the five tributaries regularly surveyed had these characteristics. Regarding future genetic studies that may occur, it will be important to recognize the early period of time when steelhead spawning can occur in Skagit basin tributary streams with subsequent early fry emergence. To indicatively represent the hatchery signal, sampling should occur that includes the earliest fry stage prior to significant depletion through natural selection from early May to mid June. After that time increasingly high depletion of hatchery and hybrid fry whose life histories may well exclude effective movements from intermittent streams or stream sections would be anticipated. In general, hatchery heritage would be

anticipated to result in increased fry/parr loss over time due to greater vulnerability to predation, or due to other factors that commonly limit hatchery related characteristics to survive as well as wild. The least effective time to find a hatchery genetic signal would be anticipated in juvenile sampling occurring from July onward, and least of all from returning adult steelhead.

Unfortunately, steelhead collections on which genetic analysis has typically been done in Puget Sound streams has been in July to September, if done at the fry level at all, and at smolt or adult life history stages. The older fry, parr, smolt, and adult life histories typically sampled have occurred long after natural selection has culled out many steelhead with some level of hatchery origin due to their reduced survival levels compared to wild steelhead. As a result, purely wild origin steelhead would increasingly dominate with increasing age after emergence and hatchery origin steelhead increasingly diminish. These are all discussions that need to occur regarding the continual references in the EA to the Ken Warheit (WDFW geneticist) genetics report. There have been numerous Warheit drafts over the past two years with resulting alterations each time, and in the case of the Skagit River his later reports increasingly eliminated the juvenile steelhead collections that were made in their earlier life histories. Even using the fry samples taken, the fry collections made in the Skagit basin were in August rather than including samples in the period of May to mid-June when the hatchery genetic signal would presumably be strongest. This is likely the similar case in all of the Puget Sound basins included in the Warheit genetics report (no matter which draft). This is remembering that his earlier report in Pflug et al. 2013, that included juvenile samplings, had found significantly greater hatchery introgression than his later drafts, but none of which has been peer reviewed. The Todd Kassler (also WDFW geneticist) genetic determinations in the same Pflug et al. 2013 report also found considerable hatchery introgression using both juvenile and adult samples taken.

Of obvious concern, given the actual field evidence from spawning surveys in the Skagit basin tributaries that include the time period of January to mid-March, hatchery/wild spawning interactions were clearly observed and documented. The evidence also indicates this has not been a token occurrence, with large overlaps in hatchery and wild steelhead spawning times as found in these tributaries that once supported 65-80% of all spawning in the basin but no longer do. Why has the Warheit report continually referred to in the EA been unable to detect hatchery/wild spawning interactions that are occurring? This is the obvious question. One reason could be that the lack of Chambers Creek origin survival in the wild is so complete that even at the hybridized level it is lethal. If so, that is not encouraging as it has been passing on this lethal trait with each year's return of hatchery steelhead to the wild population it has bred with and resulting diminishment of the genetic material of the wild steelhead that have been bred with. Another reason could be that the Chambers Creek genetic limitations last somewhat longer but disappear prior to typical August collection periods of fry, and even less evident by time of smolt and adult life histories. The third reason is due to either lack of sufficient genetic analytical skills to distinguish the hatchery signal (seems unlikely), or due to choice of a methodology that is inadequate to the job at hand (more likely).

For whatever reason there is a great disconnect between field evidence and that of a laboratory genetics technician who has little or no field experience to draw from other than what is provided to him in the way of samples. Just this winter of 2015, WDFW did do at least some steelhead spawning surveys at one of the tributary creeks where early spawning had been documented in the Mid Skagit O.mykiss Reproductive Ecology reports somewhat earlier in 2015. This included the field observation by the WDFW survey crew of hatchery/wild interactions in the Mid Skagit basin on January 28 and 29 after I found their ribbons marking the redds (pers. comm. Andrew Fowler of WDFW).

Furthermore, apparently the Upper Skagit tribe also initiated early steelhead spawning surveys at Nookachamps Creek of the Lower Skagit basin in February of 2015 (pers. comm. Dave Pflug of Seattle City Light) with subsequent GPS recordings of redd locations by WDFW (pers. comm. Brett Barkdull of WDFW). Over 100 presumed steelhead redds were apparently found in the month of February and by end of March over 200 total steelhead redds were counted in what is otherwise considered a highly degraded stream system that had received little or no steelhead spawning survey attention in recent history. There was no attempt to determine hatchery from wild, but there was an obvious significant overlap in overall steelhead spawning time at Nookachamps Creek with Chambers Creek steelhead.

As field work increasingly monitors what the actual breadth of wild steelhead spawning time is in Puget Sound mainstem tributary creeks, or otherwise small independent streams, the long perpetrated isolation/segregation myth that Chambers Creek hatchery steelhead spawn times and return times have insignificant overlap will be refuted, but which still continues to be used in this EA. This is despite this information having been made available to NOAA/NMFS, Skagit tribes, and WDFW in January of 2015 prior to the deadline of the Puget Sound Hatchery DEIS for public comment – and despite the use of this information having spurred WDFW and the Skagit tribes to initiate earlier spawning surveys that corroborate, rather than refute, the prior Mid Skagit basin tributary report findings. It also further deepens the level of concern about the Warheit genetic findings being advocated by this EA and again indicates the need for the level of scrutiny of an EIS.

Historic Evidence of Skagit River Tributary Within-Basin Genetic Differences

In 1981 a Steelhead Progress Report came out as a mutual project between WDFW and the U.S. Fish and Wildlife Service (USFWS) that included a one year sampling in 1979 of 57 areas of the Skagit basin for age 0+ steelhead for electrophoretic analysis that was done at the time (Phillips et al. 1981a). It was found:

Gene frequency differences between individual tributary samples contributed the greatest variability of all sample comparisons ... The greatest significant difference ($P < .0001$) in frequencies occurred in comparisons between tributaries.

This report has proven difficult to find anywhere, but was available at the Washington

State Library. Unfortunately, key portions of the original paper were left out in the few copies of the report that were eventually distributed. Nevertheless, it was clear that at that time there was significant within-basin genetic differences found in the tributary creeks. Although the study design had been for three years, it was terminated after only one year, but it remains that even today juvenile steelhead collections from which genetic determinations are being made are commonly limited to one year. The 1979 collection sites in the Skagit basin are clearly indicated in the 1981 report and there remains the opportunity to replicate collections there today from which valuable comparisons can be made to the 1979 findings.

From the more recent tributary surveys of 2010-2014 in the Mid Skagit basin, there are differences in hydrologies at each stream that could well result in necessary genetic adaptations to each in spawning, emergence, and juvenile migration strategies. However, it is also clear that Chambers Creek origin steelhead have been spawning in these tributaries in overlapping time periods with wild steelhead as found and photographed in the recent reports. These are all discussions necessary to making hatchery decisions that this EA entirely side-steps.

Comments to APPENDIX A, Genetic effects analysis of early winter steelhead programs proposed for the Nooksack, Stillaguamish, and Dungeness Basins of Washington:

Hatchery Smolt Residualism and Precocious Male Parr:

"However, one concern that has been raised in connection with these segregated steelhead programs is that due to the low expected reproductive success of early winter steelhead spawning in the wild, the reproductive potential of natural-origin fish that spawn with hatchery-origin fish is completely wasted. Loss of the reproductive output of these fish thus reduces the size of the spawning population and therefore the genetically effective size of the population. Although we do not consider this a realistic viewpoint, it is a useful analysis in highlighting how much lower than expected the actual amount of interbreeding between hatchery-origin and natural-origin may be. Figure 1 is a schematic of the expected distribution of hatchery-origin and natural-origin spawners over time. Although the difference varies from basin to basin, the early winter steelhead have an earlier spawn timing than natural winter steelhead. This means there will be a time during the spawning season when hatchery-origin steelhead can only spawn with other hatchery-origin steelhead (Region A), an overlap period when hatchery-origin and natural-origin steelhead can spawn amongst themselves or with each other (Region B), and a period when natural-origin steelhead can spawn only with natural-origin steelhead (Region C)...."

"A potential shortcoming of this "region" approach to spawning is that it assumes that all the spawners are returning adults. Resident *O. mykiss* (rainbow trout) and precocious residual hatchery juveniles may also be involved, both of which would not have been counted as part of the escapement. McMillan et al. (2007) noted both types of males participating in mating in the later part of the spawning season in an Olympic peninsula stream, but it is unclear what their net reproductive contribution was. Measurable reproductive success of non-anadromous males was noted in another Olympic peninsula stream that has no hatchery program

(Seamons et al. 2004b). The relative abundance of anadromous and non-anadromous *O. mykiss* is not well known in most Puget Sound streams (Myers et al. 2014). Residualism rates for the programs in the proposed action are not known. A recent meta-analysis of steelhead programs found an average residualism rate of 5.6%, ranging from 0 to 17% (Hausch and Melnychuk 2012). Genetically, residual males are of no concern unless they are sexually mature. Although historically high rates of precocious maturation have been reported (e.g., Schmidt and House 1979) and groups can be generated with rates as high as 100% (e.g., Sharpe et al. 2010), the rate in WDFW steelhead 1 releases tends to vary from 1 to 5% (Tipping et al. 2003)."

Although this is referred to in the Appendix of the EA, it nowhere has stimulated any discussion about this problem in the actual EA. It has apparently been simply blown off despite the obvious fact that even if smolt residualism is at the lowest levels known of 1-2%, it can translate into a significant number of sexually mature Chambers Creek hatchery males ready to spawn in the month of May on their release if most of those residuals are precocious male parr. Wild female steelhead in some areas of Puget Sound river basins are at peak spawning activity in May. Obviously no isolation/segregation in spawning time would then separate Chambers Creek males from spawning with them. In recent personal communication with John McMillan about the Quileute basin observations where the cited study occurred (McMillan et al. 2007), he indicated that despite the volitional release of winter steelhead smolts it did not prevent the observation of large numbers of residual smolts found in the snorkel surveys that included precocious male parr sighted on the spawning grounds with wild female steelhead. Why would it prevent such? Obviously these fish are not driven by changes to the smolt life history, but rather by changes to a mature spawning life history with the need to find a mate. Why would they remain in a hatchery rearing pond without mature females? They have to leave to do so. Furthermore, the "Pied Piper effect" was long ago documented regarding hatchery smolt releases attracting rearing wild fish to be attracted to go with them at the Wenatchee River (Hillman and Mullan 1989), and its equivalent was found regarding Norwegian hatchery Atlantic salmon smolt releases (Hansen and Jonsson 1985). While it may be the case that volitional release of smolts, as advocated in the EA, may reduce the number of hatchery smolts that residualize, that it eliminates such is highly unlikely and even more unlikely for precociously mature male parr that have the mature life history demand to leave. Even in the case of a seemingly small plant of 10,000 hatchery steelhead smolts as the preferred alternative for the Dungeness River, if only 1-2% of the resulting fish are precocious male parr, the would number 100-200 mature, ready-to-spawn Chambers Creek origin males. Shamefully, and in violation of the Boldt Decision escapement ruling requirements, there are only two years of wild steelhead escapement data for the Dungeness as indicated in the 2014 HGMP: 2010-11 at 410 natural origin spawners; and 2012-13 at 564 natural origin spawners. If half of the natural spawning population is male it results in 205 and 282 wild males in those respective years that would include 100-200 Chambers Creek hatchery precocious male parr looking for steelhead mates in the Dungeness basin – half, to fully as many wild steelhead males. This is on top of the straying anadromous Chambers Creek hatchery origin males for which spawning surveys in the basin know little or nothing as indicated by the lack of escapement data collected. This is not science, this is not good fisheries husbandry, and this is not an example to provide any confidence in the ability of WDFW

and PSTT in their supposed ability to effectively monitor the effects of hatchery programs on the wild population. This is nothing but irresponsible neglect from which any potential for so-called adaptive management is non-existent – or any other effective management other than pumping out hatchery smolt levels.

In the case of the Nooksack the plan is to release 150,000 Chambers Creek hatchery origin smolts. If only 1-2% of these are precocious male parr it results in 1,500-3,000 mature, ready-to-spawn, males. There are only escapement data of wild steelhead for 5 years of which all 5 occurred in the 10-year period of 2004-2013 with an average in those few years of 1,760 natural origin steelhead spawners. If half of those are male, it represents 880 anadromous wild males with nearly 2-4 times as many Chambers Creek hatchery origin precocious male parr looking for mates in the basin each year on top of what anadromous Chambers Creek hatchery males stray into the wild spawning grounds – and which they will, as well indicated in the recent Skagit River tributary spawning surveys.

In the case of the Stillaguamish it is planned to release 130,000 Chambers Creek hatchery origin smolts. If only 1-2% are precocious male parr it results in 1,300-2,600 mature, ready-to-spawn, males. The average escapement of Stillaguamish basin wild steelhead has been estimated at 1,852 from 2001 to 2012. If half are males it is 926 wild anadromous males that are outnumbered by 1.5 to almost 3 times as many Chambers Creek hatchery origin precocious males looking for mates in the basin each year on top of what anadromous Chambers Creek hatchery males stray into the wild spawning grounds – again anticipated to be particularly significant in the tributary creeks as found in the Mid Skagit basin tributary examples.

It is apparent that all involved in this EA process have chosen not to consider anything that stands in the way of resumed Chambers Creek hatchery plants by ignoring the hatchery precocious male parr problem.

Comments to 3.3.4. Incidental Fishing Effects:

"Prior to the 1990s, hatchery-origin steelhead were not mass-marked with an adipose fin clip. 10 Therefore, anglers could not easily differentiate between natural-origin and hatchery-origin 11 steelhead. Fish managers tried to minimize harvest impacts on natural-origin steelhead by 12 closing the fisheries that targeted earlier arriving hatchery-origin steelhead before the natural-13 origin winter-run populations arrived. However, fishermen may have inadvertently harvested the 14 earliest-returning natural-origin steelhead, which may have changed the overall run timing of the 15 population [i.e., evidence suggests that, historically, the natural-origin winter population had a 16 larger proportion of adult fish returning prior to February (Myers et al. 2014)]."

Diminishment of Wild Steelhead Early Run-Timing

In the above, it is again disregarded that harvest from tribal and sport fishing has altered the run-timing of wild steelhead as an important life history characteristic. Nowhere in the EA is it considered beyond being hidden away in this Appendix reference. This is

despite the fact that the authors of Myers et al. 2014 include those from NOAA, WDFW, and PSTT, and members of the Puget Sound Steelhead TRT.

Figure 7 portrays the historical steelhead tribal catch data from 10 rivers in the Boldt Case area of Washington are available in WDFW files from 1934 through 1959 (Taylor 1979), a period when most returning steelhead were wild with highly dominant catch between November and February, and much less in March-April. These data were examined, tabulated, and put into graphic form and subsequently provided in a presentation to the Pacific Coast Steelhead Managers Meeting in Boise, Idaho in 2008 (McMillan 2008). One river of the three included in EA being commented on, the Nooksack, had historical tribal harvest data from 1951 to 1959 as shown in Figure 8.

Also included were comparative sport fishing harvest data detailed in steelhead punch card returns from a similar comparative era from 1948 to 1959. Prior published reports have provided the sport catch by month in that era demonstrating the predominance of early steelhead run-timing in December through February as compared to generally smaller sport catch in the March-April later return period. Figure 9 provides the steelhead sport catch for the Nooksack River in the winters of 1954-55 and 1955-56 which would be nearly all wild steelhead as can be seen from the hatchery plant history in Figure 2. Figure 10 provides the sport catch in Washington for 1949-1951 by Larson and Ward (1955) when all steelhead would have been wild. Figure 11 provides the sport catch in Washington from 1954-1960 from Royal (1972) when most steelhead would have been wild and prior to the first returns of the modern hatchery steelhead program in Washington in 1962 with 1960 escalation of plants and better smolt survival due to increased nutrition in the hatchery rearing diet (Royal 1972).

Figure 7.

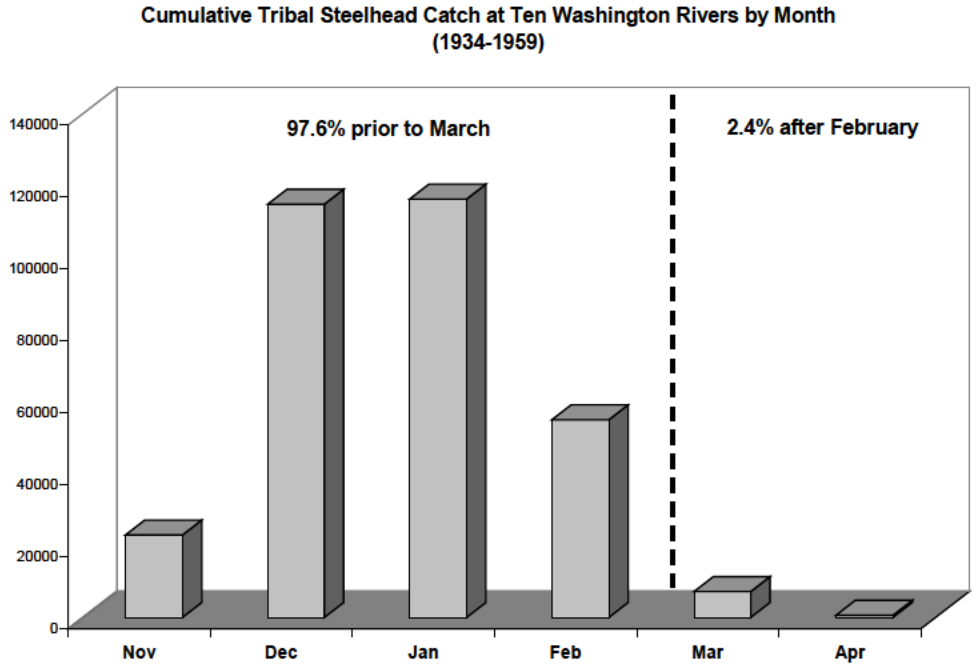


Figure 8.

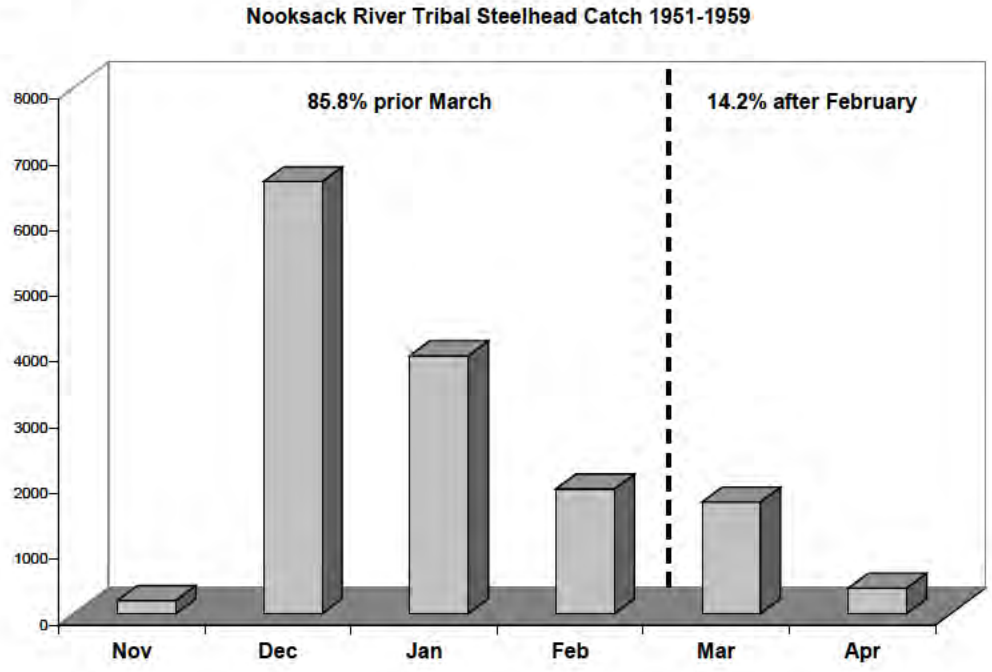


Figure 9.

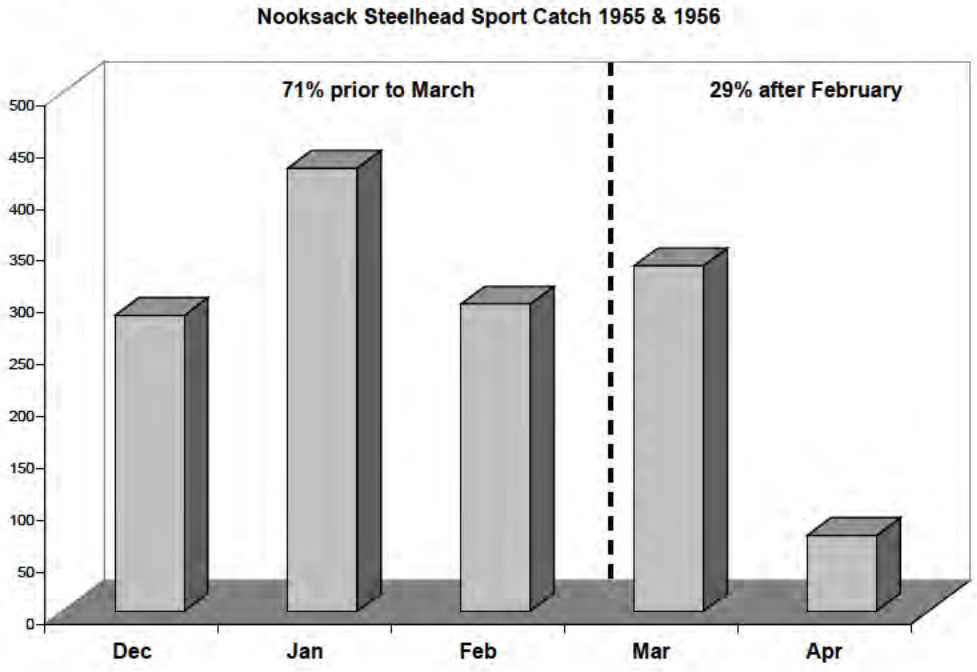


Figure 10.

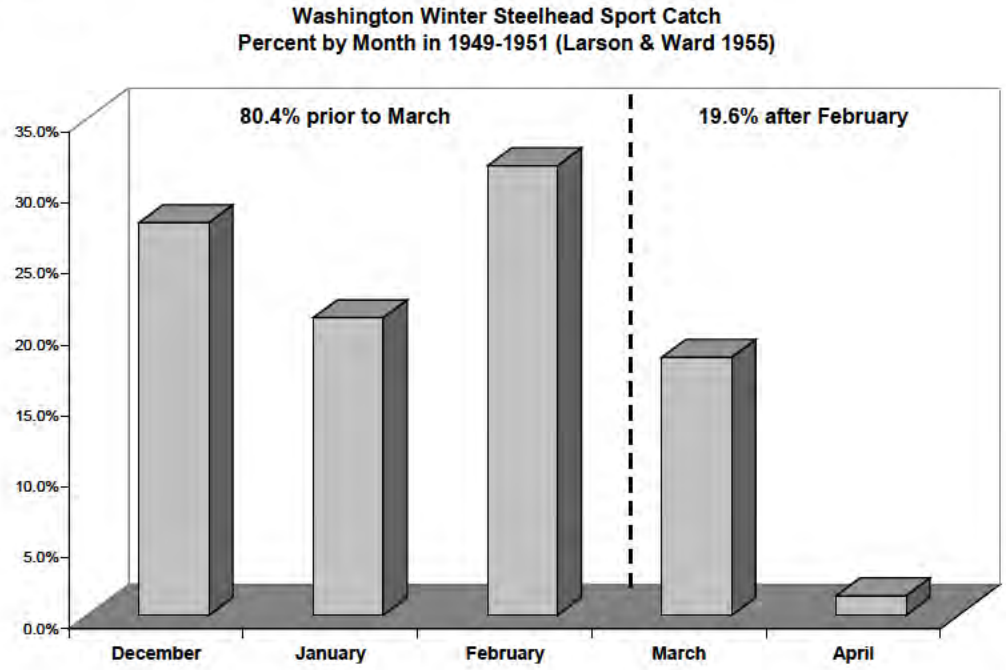
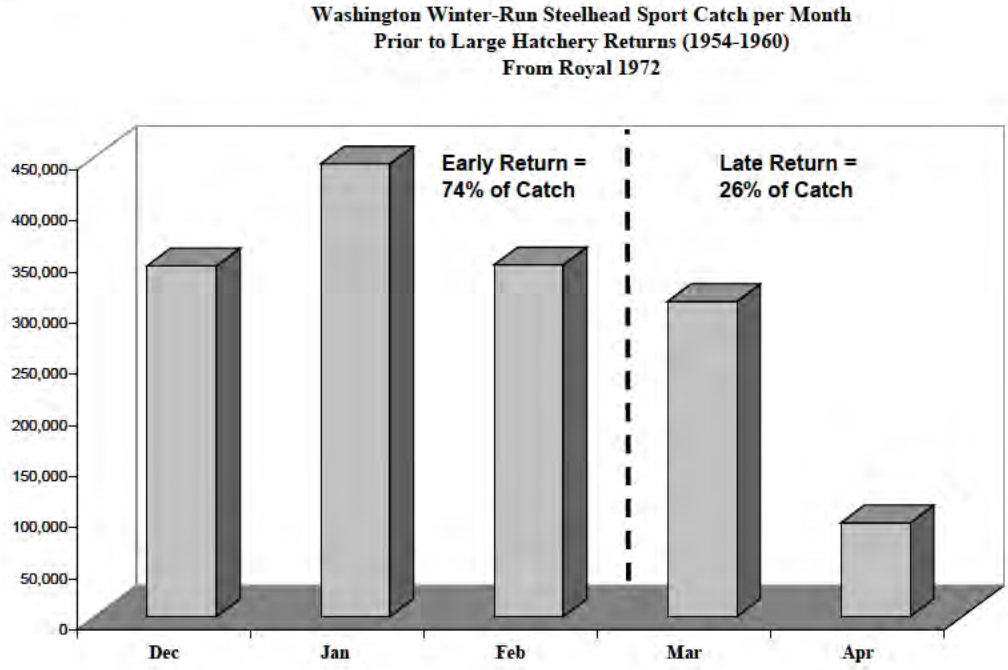


Figure 11.



It was described by Pautzke and Meigs (1941) that the steelhead sport fishery was only open for the 1939 and 1940 seasons in January and February at the Green River, and yet sustained a healthy and attractive sport fishery to the anglers of the era – all wild fish.

It is clear from all these Washington cumulative historical winter steelhead harvest data that winter steelhead run-timing prior to the modern hatchery program was dominated by wild steelhead that returned in the December through February time period coinciding precisely with the dominant run timing of Chambers Creek hatchery steelhead.

In the data portrayed at the 2008 Pacific Coast Steelhead Managers Conference (McMillan 2008), it was shown in graphed depictions from several Washington rivers that tribal catch was dominated by early return steelhead somewhat more so than the sport catch. It was explained that this is an understandable pattern. Tribal catch is commonly limited to the lower reaches of rivers while sport catch occurs over more extensive river reaches that often includes into the steelhead spawning grounds. Therefore tribal catch portrays initial steelhead migrations into the rivers while sport catch includes steelhead that have held in the river for considerable time in wait for spawning activity. The latter characteristic of early return steelhead to remain in a river system longer than later return steelhead was found in the Skagit River steelhead acoustic tracking studies (Pflug et al. 2013) and which makes them more vulnerable to harvest as found many years earlier by Hooton and Lirette (1986) at the Gold River of Vancouver Island during telemetry-tracking studies there. The early winter steelhead at Gold River were commonly found to hold for 3-4 months in the area most heavily fished by sport fishermen. This also makes them more vulnerable to catch-and-release angling mortality as a result of potential multiple angler encounters (Hooton 2001). A further reason for tribal catch being a better reflection of actual steelhead migrations in the early-return period is because Pacific storms in November through January result in commonly high and discolored stream flows that limit the effectiveness for sport fishing but which may not be as limiting for gill net fisheries, and in some instances may be advantageous. By contrast, the more stable flows after January and more dependable water clarity are advantageous for sport fishing. Yet another reason for sport fisheries to show somewhat later run timing for winter steelhead than the tribal fisheries is that the lower river reaches commonly targeted by tribal fisheries results in the harvest of considerable numbers of early return steelhead before they reach the more extensive sport fishing areas upstream.

How has the formerly dominant early return wild steelhead life history fared since the 1960s with the initiation of the modern steelhead hatchery program using Chambers Creek steelhead as the supposed primary driver of harvest opportunity? This is the history and discussion that need to occur from which effective Puget Sound steelhead recovery decisions can be made, but are being utterly disregarded in this EA process. Unfortunately there are little data since the 1960s from which to determine what wild steelhead run timing is today, but we do know that it is proclaimed for management purposes to no longer exist in significant numbers according to the 2004 Draft EIS for the proposed Lower Skagit River steelhead acclimation-rearing pond (WDFW 2004), and in this EA. The WDFW and PSTT mythical assumptions have been that Chambers Creek steelhead provide differential harvest opportunity due to being isolated/segregated from

wild steelhead in run time. This myth is purely policy driven and is not based on any actual evaluation of data that is required from which to effectively manage for the harvest and escapement of wild steelhead as the Boldt Decision clearly ruled as the basic conservation need for sustainable populations and fisheries.

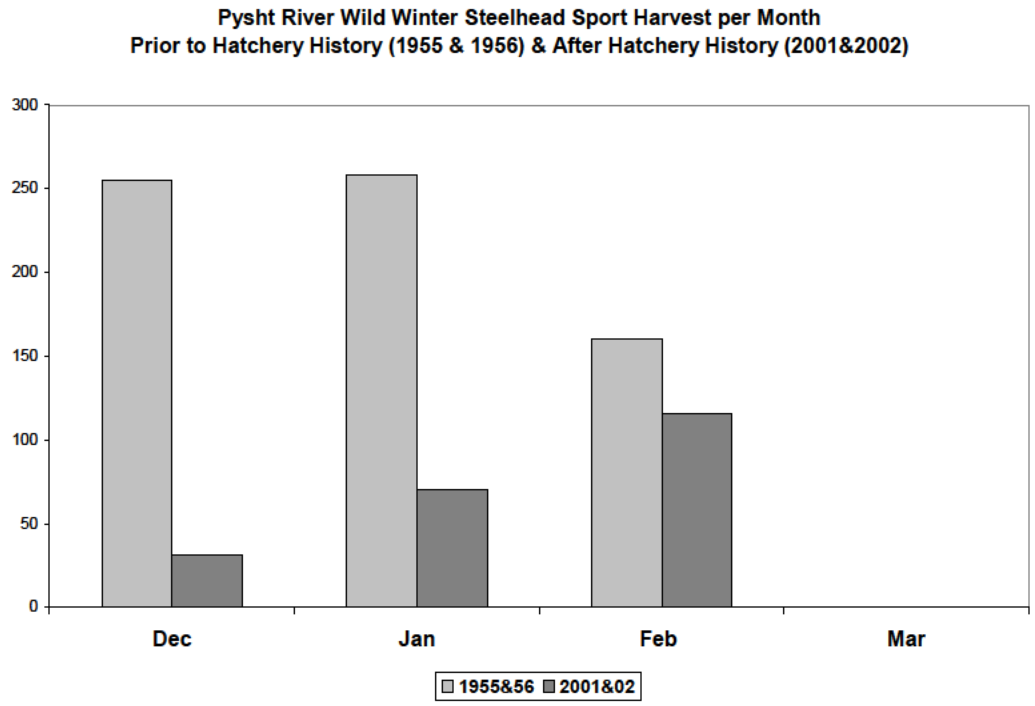
In the case of the Dungeness, Nooksack, and Stillaguamish rivers there have been no available data provided from which to determine what the present run timing of wild steelhead is, now primarily limited to tribal fisheries. In the case of the Nooksack, from 1980 to the present the only tribal steelhead harvest data available regarding wild as separate from hatchery is from 1980 to 1988, and that is only total numbers – not that needed by week or month (Scott and Gill 2006). There is absolutely nothing available to the public since that time from which to track how life history shifts in wild steelhead run timing might have occurred over time, or what remains today. The Boldt Case ruling clearly stipulated that the treaty tribes had to provide their harvest records to the Washington fish managing agencies at that time, now limited to WDFW. Similarly, escapement data needed to be cooperatively collected from which to meet the conservation requirements for sustainable returns and their fisheries. All of this is lacking but for relatively few years in the Nooksack and would seem in complete violation of the Boldt Decision rulings if harvest fisheries are to occur. Beyond that legal mandate is the scientific basis for any effective fishery management which NOAA/NMFS, WDFW, and PSTT should be bound by as most basic requirements for sustaining fish populations, let alone those that are ESA listed that require recovery. This problem is not limited to the Nooksack.

The Dungeness and Stillaguamish are even worse than the Nooksack. There are absolutely no tribal harvest data broken out by hatchery and wild, just total numbers, and no breakdown by week or month (Scott and Gill 2006).

Nevertheless, there are data available that indicate what run timing shifts have occurred for Washington wild winter steelhead. At the Pysht River on the Strait of Juan de Fuca, hatchery steelhead introductions began in 1957, first adult returns 1959 (WDG 1948-1972), and have been continuous since 1959 (WDG 1948-1978; Scott and Gill 2006). The monthly sport catch of wild steelhead at the Pysht was documented in the winters of 1954-55 and 1955-56 (WDG 1956; WDG 1957). The wild sport catch is available for the winters of 1994-95 and 1995-96 (WDFW Sport Catch Summaries) which is 36-37 years after Chambers Creek origin hatchery steelhead introductions. This is the last period of time when sport harvest for wild steelhead was recorded. Figure 12 provides the comparisons in wild steelhead sport harvest per month in this period of time showing the reversal in run timing from primarily early to that of later. Tribal steelhead harvest records began in the Pysht River in 1974-75 with catch by month through 1978-79, but by then it was a combined catch of hatchery and wild (Taylor 1979) and there is no subsequent monthly record of wild tribal catch since (Scott and Gill 2006).

The historic Skagit basin predominantly wild steelhead sport catch in the winters of 1954-55 and 1955-56 is shown by month in Figure 13 (WDG 1956; and WDG 1957). The Skagit is the next river basin to the south of the Nooksack and the next north of the

Figure 12.



Stillaguamish as pertinent to this EA. Presumably there would be similarities for all three. There is no significant older history of tribal harvest in the Skagit to draw from, but there are comparative steelhead sport catch data by anglers who kept good records across two time periods. The steelhead catches of Bellingham angler Ralph Wahl are available at the Western Washington University Center for Pacific Northwest Studies. His primary steelhead fishing destination was the Skagit River, with each fish recorded by day, month, year, and weight. He kept good record of their weight as required for submissions he made to the *Field and Stream* magazine annual sport fishing contests. Prior to his death we had compared steelhead fly fishing observations, both of us using the same methods while fishing the Skagit basin. Ralph's most active fishing years were 1936-1955, of which I recorded his catch which was prior to significant contribution of hatchery steelhead. My primary fishing of the Skagit basin for steelhead has been 1999-2012 – a period of time long after Chambers Creek hatchery origin steelhead (and Skamania hatchery origin summer steelhead) had returned in considerable numbers with subsequent harvest particularly targeting the early-return winter steelhead by both tribal and sport fisheries. The comparative differences in our catches demonstrate shifts in wild winter steelhead return time and a near elimination of wild summer steelhead between the two time periods as shown in Figures 14 and 15.

What led to this shift in winter steelhead run timing on the Skagit River and elsewhere in Washington?

Figures 16-18 provide much of the answer. As a result of being an author included in the Figure 13.

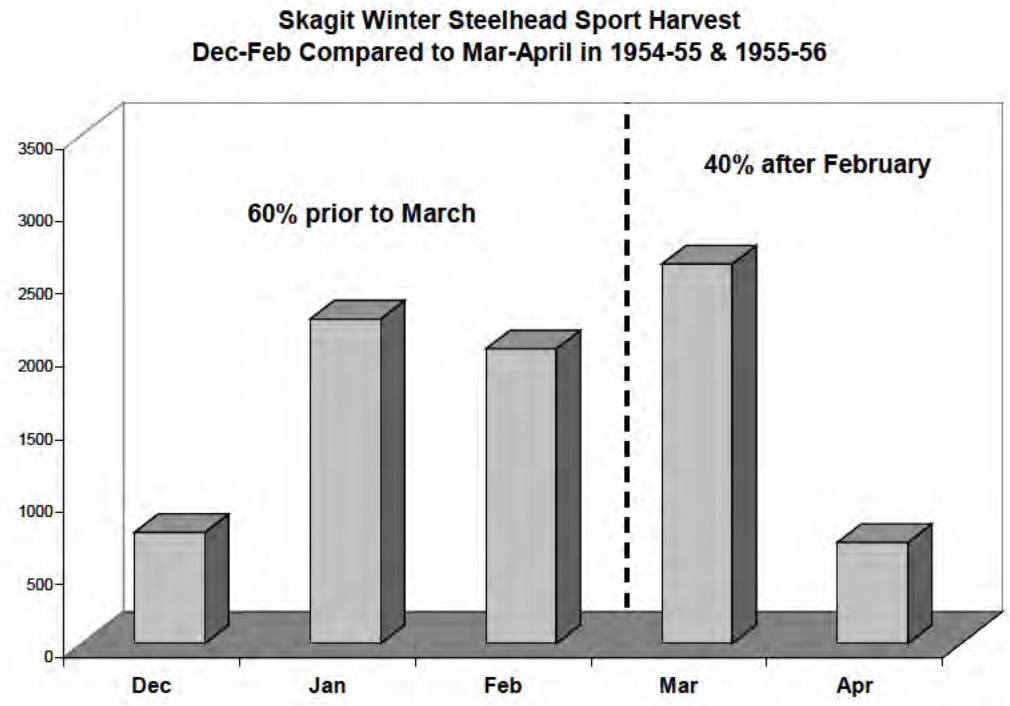


Figure 14.

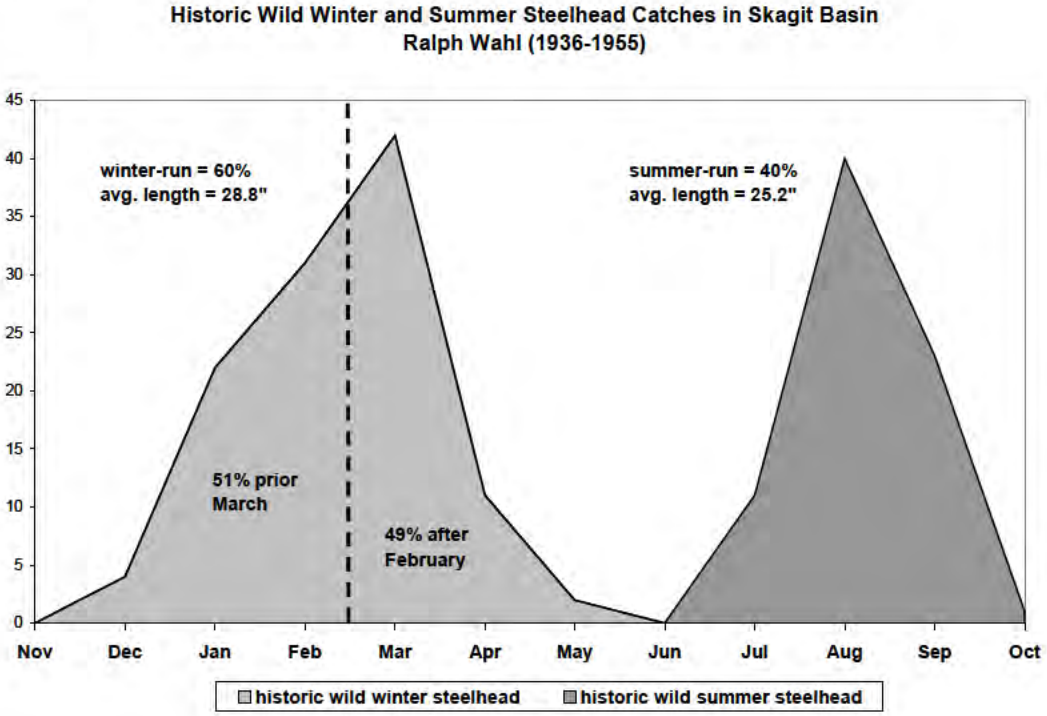
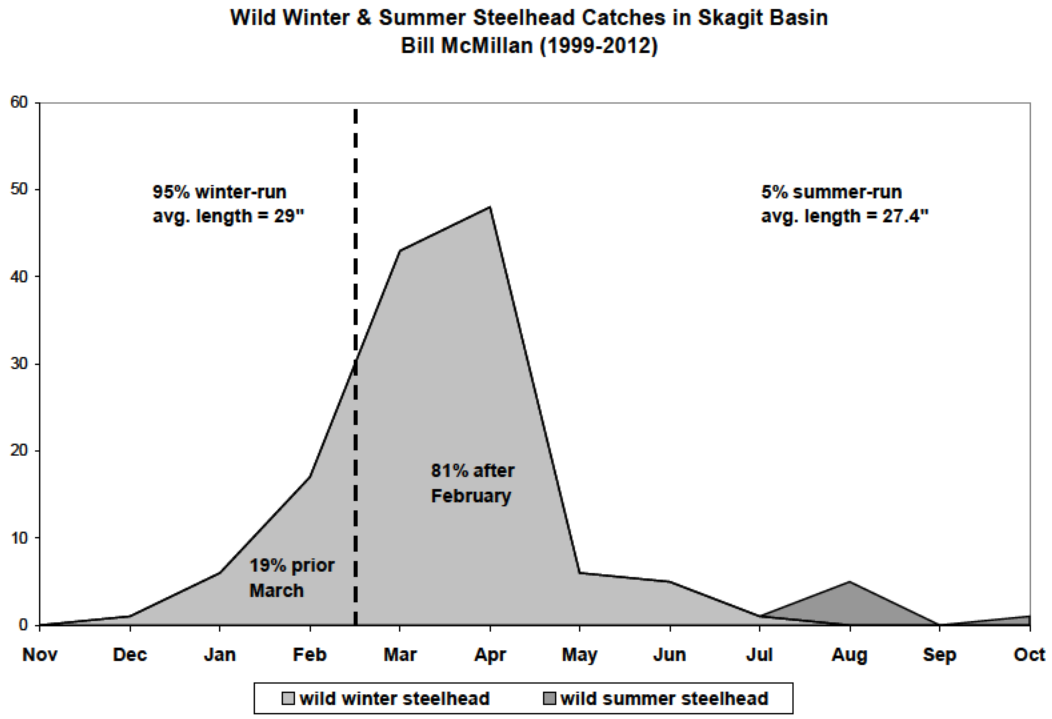


Figure 15.



write-ups of the Skagit steelhead research from 2009-2012 I was provided all of the available harvest and escapement data for tribal and sport fisheries developed by the co-managers in several large spreadsheets to draw from. The harvest data for hatchery and wild steelhead are provided by weekly intervals from 1985 to 2011 for the tribal fisheries, and by monthly intervals from 1993 to 2002 for the sport fishery (excluded 2003-2011 data due to being wild steelhead catch and release throughout the basin).

As has been described in Washington steelhead literature, 80-95% harvest rates have long targeted early return winter steelhead in the assumed isolation (or segregation) of Chambers Creek origin hatchery steelhead from wild steelhead in that time period (McHenry et al. 1996; SASSI 1994). Yet the steelhead harvest managers have the fishery data to look at every single year in their analysis required to develop return forecasts from which to plan the coming fishery seasons. Even after years of this excessive harvest rate that wild steelhead can little withstand with subsequent reductions from former predominance of early return characteristics, as shown in the following figures they have continued to represent a significant component of the early-return catch – in some cases predominantly so. This altered beginning in 2003 in the Skagit basin when harvest of wild steelhead in the sport catch was theoretically eliminated with catch-and-release regulations for the first time year around. However, despite what is likely reduced fishing effort on the part of the Skagit tribes since the begin of the collapse of the steelhead returns in 2001, as shown in Figure 18 the proportion of the early tribal catch that is wild has further increased from what it was prior to that time as conveyed in Figure 16. Yet, due to the continuing presence of Chambers Creek origin hatchery steelhead in the periods depicted, without high harvest rates on the early steelhead return component there would be many more of those hatchery steelhead further straying into

Figure 16.

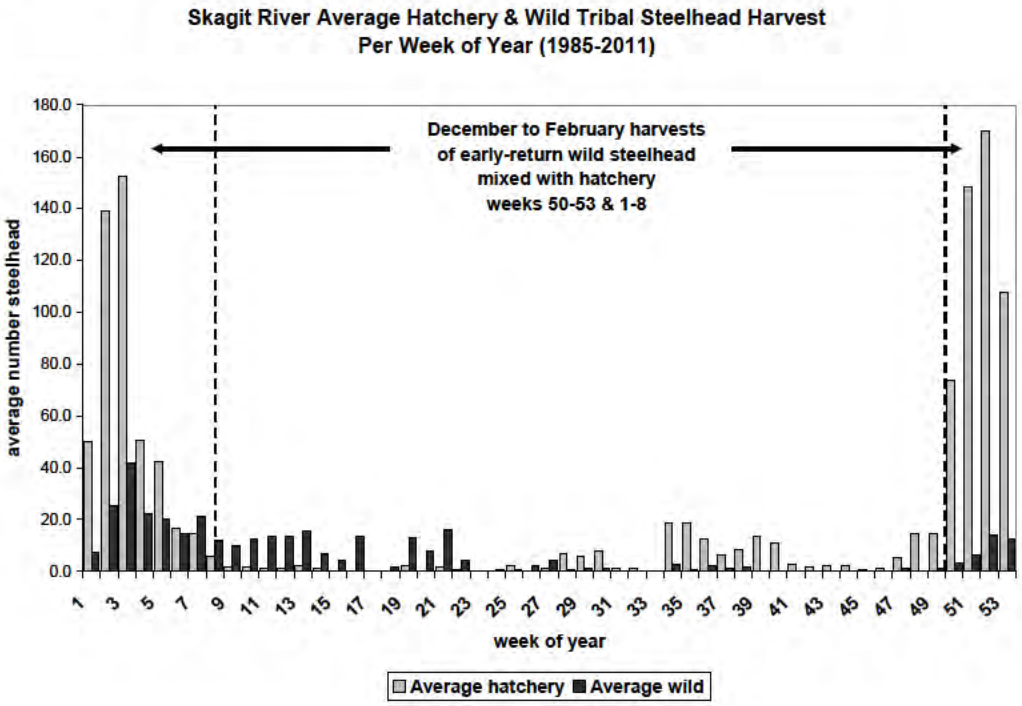


Figure 17.

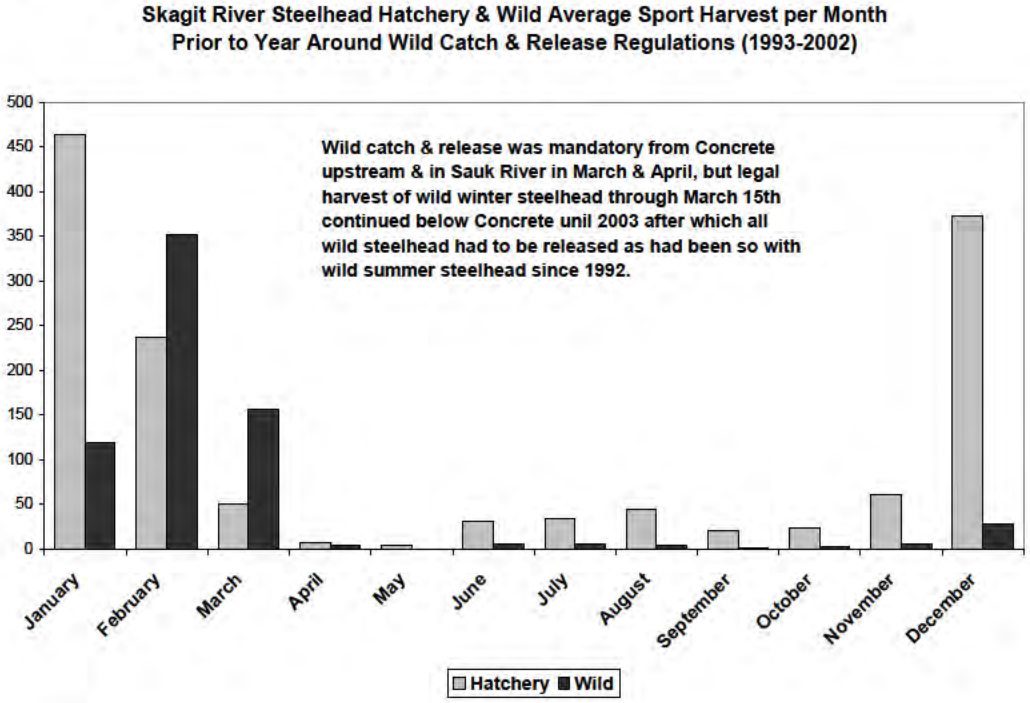
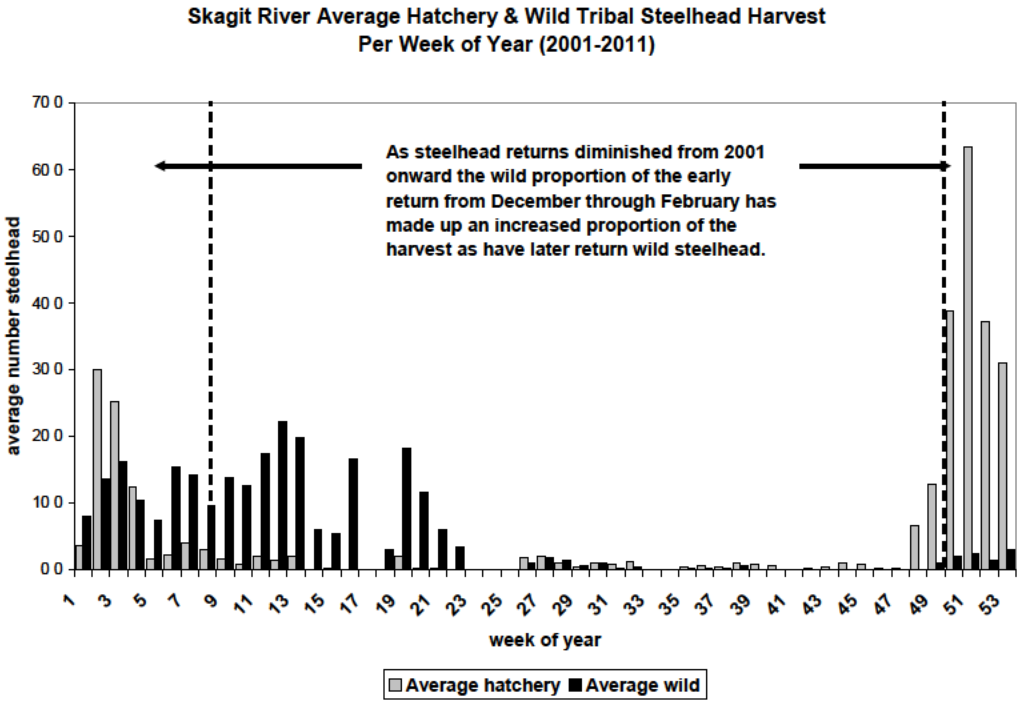


Figure 18.



the spawning grounds than what already occurs as previously shown in the Skagit tributary creek spawning survey results. As long as Chambers Creek origin hatchery steelhead are present, recovering the depleted early run component of wild steelhead that historically dominated in Washington rivers simply can't occur due to the need for harvest rates that wild steelhead can't productively sustain. Yet management is trapped "between a rock and a hard place" in which nothing can be done to provide a steelhead future other than a continuing downward spiral as long as Chambers Creek origin hatchery steelhead are present.

All of this is at the heart of the necessity of a full EIS in whatever hatchery evaluation process occurs, whether that for Chambers Creek origin hatchery fish or that of wild broodstock. The discussions that occur have to honestly confront all of the above that has been provided in these comments, and more, not hide from them in the continued fabrication of steelhead management myths that have been the hallmark of Washington steelhead management the past 40-50 years with the inevitable results that have occurred in Puget Sound.

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APPENDICES

Appendix A

From: http://www.ccrh.org/comm/river/legal/boldt.htm

Document:
Boldt Decision

UNITED STATES of America, Plaintiff, Quinault Tribe of Indians on its own behalf and on behalf of the Queets Band of Indians, et al., Intervenor-Plaintiffs, v. STATE OF WASHINGTON, Defendant, Thor C. Tollefson, Director, Washington State Department of Fisheries, et al., Intervenor-Defendants

Civ. No. 9213

UNITED STATES DISTRICT COURT FOR THE WESTERN DISTRICT OF WASHINGTON, TACOMA DIVISION

384 F. Supp. 312; 1974 U.S. Dist. LEXIS 12291

February 12, 1974

IV. RULINGS ON MAJOR ISSUES IN THIS CASE

.....

QUALIFICATIONS

The tribe shall:

(a) Provide for full and complete tribal fishing regulations which, before adoption, have been discussed in their proposed final form with Fisheries and Game, and include therein any state regulation which has been established to the satisfaction of the tribe, or upon hearing by or under direction of this court, to be reasonable and necessary for conservation.

(b) Permit monitoring of off reservation Indian fishing [**49] by Fisheries and Game to the extent reasonable and necessary for conservation.

(c) Provide fish catch reports, as to both on and off reservation treaty right fishing, when requested by Fisheries or Game for the purpose of establishing escapement goals and other reasonable and necessary conservation purposes.

All parties in this case agree that on reservation fishing is not subject to state regulation and no issue to the contrary is presented in this case. Indeed, any contention to the contrary would be diametrically opposed to the Indian self-government intent and philosophy of Congress. However, state regulation of off reservation fishing to the extent reasonable and necessary for conservation requires that Fisheries and Game must have all information essential to such limited regulation. From the evidence in this case, the court hereby finds and holds that recording the number of fish taken in treaty right fishing, both on and off reservation, is essential to reliable estimates of future run sizes which are necessary for reasonably accurate calculation of spawning escapement requirements and for the allocation of harvestable fish as provided in this decision.

The lack of [**50] adequate, or any, approved identification of treaty right fishermen long has and now does seriously interfere with their fishing and hampers enforcement of both tribal and state regulations reasonable and necessary for conservation. Therefore, each of plaintiff tribes, self-regulated or not, is hereby directed to provide as promptly as practicable both (a) certification and identification of its tribal fishermen as specified in para. (f) of the above stated Qualifications; and also (b) fish catch returns as specified in para. (c) of the above stated conditions.

....

To clearly identify state treaty right fishing regulations and to make them more readily understood and usable by plaintiff tribes and others interested therein such regulations shall be published either separate and apart from other state fishing regulations or as a separate and plainly labeled part thereof readily distinguishable from other fishing regulations.

4. However broadly the word may be used and applied in the theory and practice of fisheries science and management, "conservation" as used in Supreme Court decisions and herein is limited to those measures which are reasonable and necessary to [**53] the perpetuation of a particular run or species of fish. In this context, as well as by dictionary definition, "reasonable" means that a specifically identified conservation measure is appropriate to its purpose; and "necessary" means that such purpose in addition to being reasonable must be essential to conservation.

5. The state having the burden of proof as above indicated, no regulation applied to off reservation treaty fishing can be valid or enforceable unless and until it has been shown reasonable and necessary to conservation as above defined. The arrest of, or seizure of property owned or in permitted custody of, a treaty right fisherman under a regulation not previously established to be reasonable and necessary for conservation, is unlawful and may be actionable as to any official or private person authorizing or committing such

unlawful arrest or seizure.

6. If alternative means and methods of reasonable and necessary conservation regulation are available, the state cannot lawfully restrict the exercise of off reservation treaty right fishing, even if the only alternatives are restriction of fishing by non-treaty fishermen, either commercially or otherwise, to the full [**54] extent necessary for conservation of fish.

.....

For these reasons the court finds that the taking of fish for ceremonial [**56] and subsistence purposes has a special treaty significance distinct from and superior to the taking of fish for commercial purposes and therefore fish taken to serve ceremonial and subsistence needs shall not be counted in the share of fish that treaty right fishermen have the opportunity to take. Such needs shall be limited to the number of fish actually used for: (a) Traditional tribal ceremonies; and (b) Personal subsistence consumption by tribal members and their immediate families.

By dictionary definition and as intended and used in the Indian treaties and in this decision "in common with" means *sharing equally* the opportunity to take fish n29 at "usual and accustomed grounds and stations"; therefore, non-treaty fishermen shall have the opportunity to take up to 50% of the harvestable number of fish that may be taken by all fishermen at usual and accustomed grounds and stations and treaty right fishermen shall have the opportunity to take up to the same percentage of harvestable fish, as stated above.

.....

- - - - - - - - - - - - - - - - -End Footnotes- - - - - - - - - - - - - - - - - [**57]

While emphasizing the basic principle of sharing equally in the opportunity to take fish at usual and accustomed grounds and stations, the court recognizes that innumerable difficulties will arise in the application of this principle to the fisheries resource. For the present time, at least, precise mathematical equality must give way to more practical means of determining and allocating the harvestable resource, with the methodology of allocation to be developed and modified in light of current data and future experience. However, it is [*344] necessary at the outset to establish the scope of the anadromous fish resource which is subject to being "shared equally." The amount of fish of a particular species, from which the harvestable portions allocable to treaty right fishermen and non-treaty right fishermen are to be determined, is not merely the number of harvestable fish of that species which pass through the usual and accustomed fishing places of the various treaty tribes.

It is uncontroverted in the evidence that substantial numbers of fish, many of which might otherwise reach the usual and accustomed fishing places of the treaty tribes, are caught in marine areas closely [**58] adjacent to and within the state of Washington,

primarily by non-treaty right fishermen. [Ex. F-6, 7; PL-67(b)-(c); JX-2(a), pp. 125-135; Figs. 49-54, Tables 34-60]. These catches reduce to a significant but not specifically determinable extent the number of fish available for harvest by treaty right fishermen. A considerable amount of this harvest is beyond any jurisdiction or control of the State. Some of this harvest is subject to limited state control because the landings are made in areas of state jurisdiction. A considerable number of fish taken within the territorial waters of Washington are under the regulatory authority of the International Pacific Salmon Fisheries Commission, an international body established by treaty between the United States and Canada. While the defendants cannot determine or control the activities of that Commission, the Washington Department of Fisheries does have some input into development of the harvest program which is prescribed or permitted by that Commission, particularly as it pertains to harvest within Washington waters. The Commission is essentially concerned with assuring adequate spawning escapement from runs subject to its jurisdiction [**59] and equal division of the harvestable portion between the two countries. Its control over times, places and manner of harvest is designed to accomplish those results.

....

A. Definitions

...

2. *Adequate production escapement*: In an approximate number of anadromous fish, that level of escapement from each fishery which will produce viable offspring in numbers to fully utilize all natural spawning grounds and propagation facilities reasonable and necessary for conservation of the resource, as defined in the Decision of the court.

3. *Harvestable* [**258] *stock*: The approximate number of anadromous fish which is surplus beyond adequate production escapement and Indian needs as defined in the Decision; that is, the number remaining when the adequate production escapement and Indian needs are subtracted from the run size.

4. *To preserve and maintain the resource*: Upon a full consideration of (a) the history of State anadromous fish management, (b) the level of catch within the Western District of Washington in recent years, (c) the quality of freshwater and artificial production environments, (d) the most recent facts and data concerning anadromous fish production potential, (e) the potential for interspecific competition, and (f) the prospects for improvement of anadromous fish production, to perpetuate the runs of anadromous fish at least at their current level.

....

RULINGS ON FISHERIES' QUESTIONS PER RECONSIDERATION MOTION
....

12. Where two or more Indian tribes have treaty rights to fish in the same off-reservation area, how is the off-reservation 50% treaty share to be calculated?

A. The division among tribes of the Indian off-reservation share of the harvest shall be determined by the tribes fishing in the same usual and accustomed places. The only concern of the state would be to determine (a) whether the total harvest by all tribes exceeds 50%, and (b) whether any tribe or group of tribes will cut into escapement when fishing as the tribes had planned.

Appendix B

Chambers Creek hatchery steelhead eradication timeline and smolt plants:

Figure 1. From: Cooper and Johnson 1992

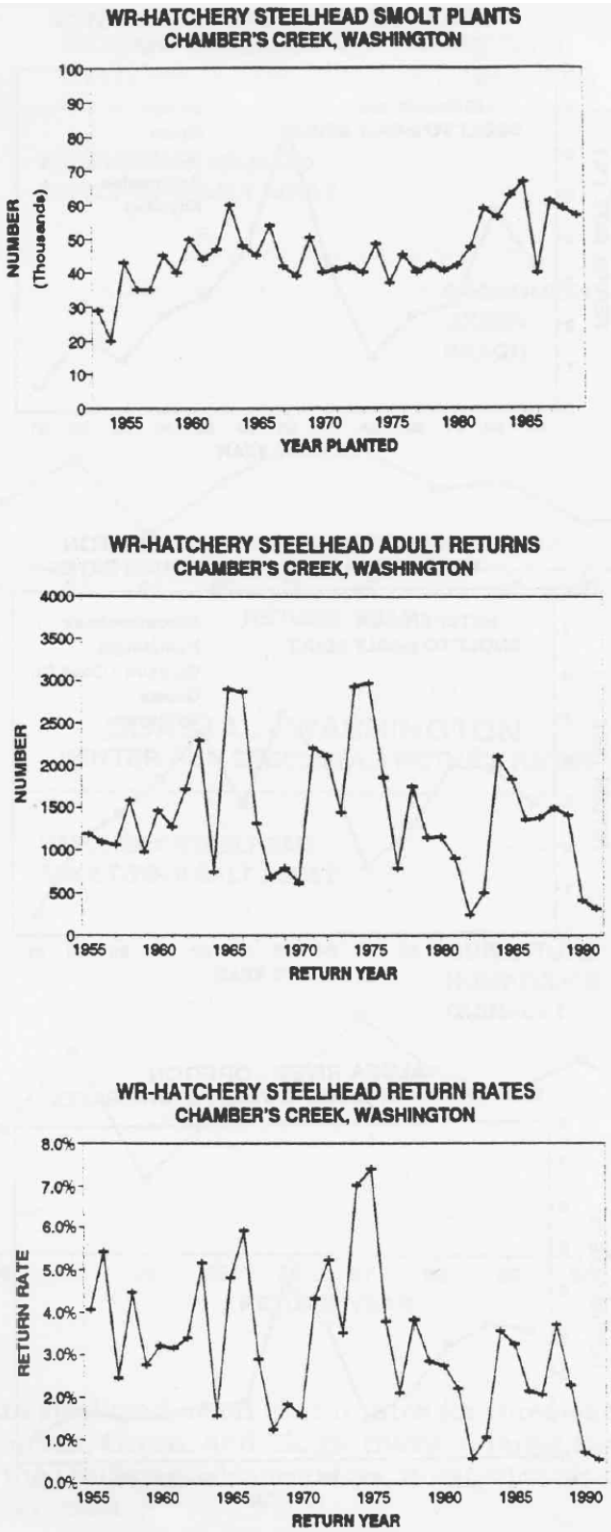
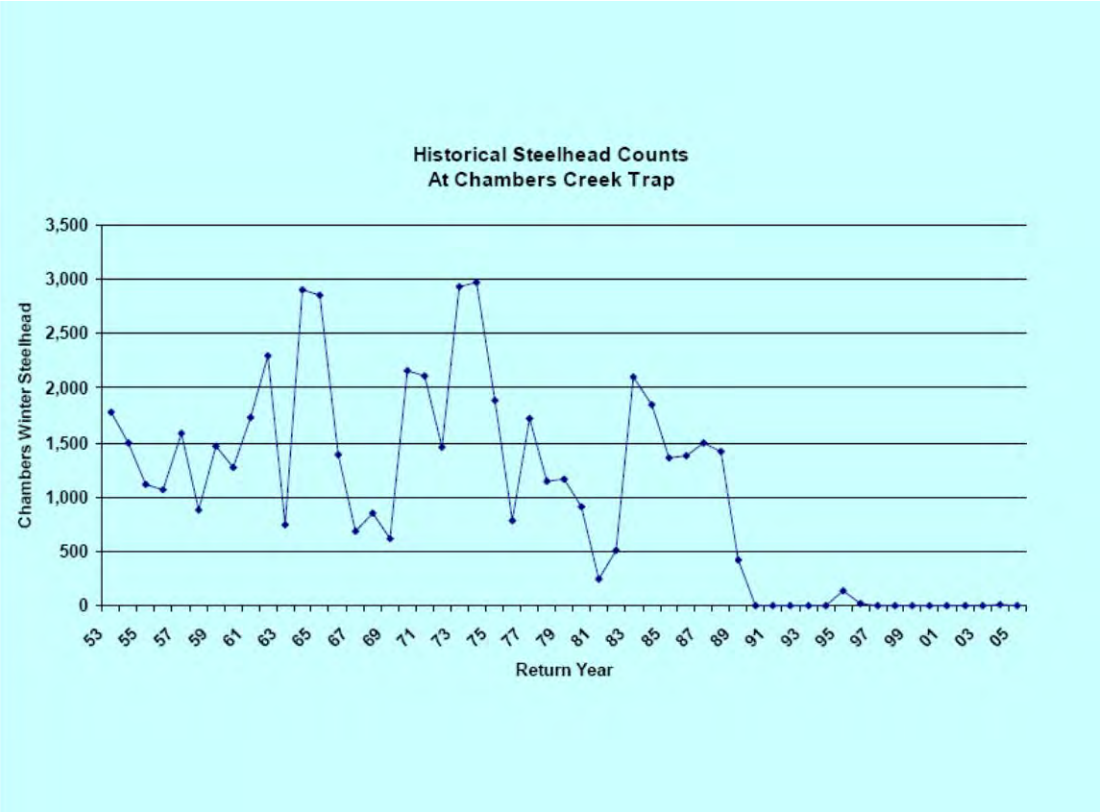


Figure 7. Winter-run steelhead smolt plants, number of adult returns, and return rates at Chambers Creek, Washington from 1953 to 1989.

http://www.co.pierce.wa.us/xml/services/home/environ/water/general/conferences/lid100507/presentations/10-Eltrich-ChambersRichPart2007.pdf

(The above was accessed in summer 2012 but was no longer accessible as of 1-20-2013.)



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Eltrich, R. 2007. Chambers Creek Hatchery Production: Historic and Present Programs. Washington Department of Fish and Wildlife. Presentation at: Chambers-Clover Watershed Conference, Pacific Lutheran University. October 5-6, 2007.

Appendix C.

Length and Computed Weight of 24 Chambers Creek Origin Steelhead from Marblemount Hatchery as Caught and Measured at the Skagit River by Bill McMillan (1998-2014) Using the Meigs and Pautzke (1941) Curve for Conversion of Length in Inches to Weight in Pounds from Several Hundred Winter Steelhead Sampled at the Green River at that Time

number	length in inches	weight in pounds using Meigs & Pautzke 1941 curve of length to weight
1	28.5	8.2
2	24	5
3	27	7.1
4	26	6.5
5	28	8
6	27	7.1
7	27	7.1
8	30	9.8
9	27	7.1
10	25	5.75
11	24	5
12	27	7.1
13	26	6.5
14	26.5	6.75
15	27	7.1
16	23	4.2
17	29	8.75
18	30	9.8
19	28	8
20	28	8
21	25.5	6
22	23	4.25
23	22.5	3.9
24	30	9.8
Avg	**26.625**	**6.95**

EWSteelheadHatcheries wcr - NOAA Service Account
<ewsteelheadhatcheries.wcr@noaa.gov>

Protect Puget Sound Wild Steelhead

5 messages

Derek Saam <derek@zahmap.com> Mon, Apr 13, 2015 at 11:12 PM
To: EWSteelheadHatcheries.wcr@noaa.gov

I'm avid steelhead fisherman and fish lover and I feel that we need to take a new approach to managing wild steelhead and salmon in our rivers. I think if we truly understood why the wild steelhead population is unhealthy we'd have solved the problem already. Since we don't know we need to make changes and look in greater detail at the environmental factors that effect our fish.

I suspect it's unnoticed and noticed diseases that are born from raising so many fish in such close quarters at hatcheries that have decimated Puget Sound and other fisheries. When hundreds of thousands of fish are raised in pens your breeding powerful super bugs with them, and while the hatcheries protect the fish with antibiotics and the hatchery fish gain immunity to many of the bacteria, parasites and viruses through rapid natural selection, the wild fish don't have that luxury and when those hundreds of thousands of disease vectors get released in our streams, not to mention the water discharges from the hatchery systems they infect the wild populations. The fish were never meant to be bred in such density and it's one of the silent killers that make hatchery's environmental disasters.

Whatever the reason our wild salmon are in decline, to bring the population back we need to make changes and rebuild their natural environment as best we can and I think this means bringing an end to the wasteful hatchery programs and at the very least heavily monitoring its environmental impact. Why not just shut them down for ten years and see what happens, a lot could be learned about their effects.

--
Derek Saam
derek@zahmap.com

EWSteelheadHatcheries wcr - NOAA Service Account Mon, Apr 13, 2015 at 11:12 PM
<ewsteelheadhatcheries.wcr@noaa.gov>
To: saamde@gmail.com

Thank you for commenting on the early winter steelhead hatcheries pending determination and draft environmental assessment. The comment period for this action will close at 5 p.m. Pacific time on [date of end of comment period].

EWSteelheadHatcheries wcr - NOAA Service Account Tue, Apr 14, 2015 at 8:36 AM
<ewsteelheadhatcheries.wcr@noaa.gov>
To: Allyson Purcell - NOAA Federal <allyson.purcell@noaa.gov>, James Dixon - NOAA Federal <james.dixon@noaa.gov>
Bcc: Tim Tynan - NOAA Federal <tim.tynan@noaa.gov>

Forwarding first public comment received in the mailbox "ewsteelheadhatcheries.wcr@noaa.gov".
[Quoted text hidden]

Derek Saam <saamde@gmail.com> Tue, Apr 14, 2015 at 4:48 PM
To: EWSteelheadHatcheries wcr - NOAA Service Account <ewsteelheadhatcheries.wcr@noaa.gov>

As a follow up, I found this paper interesting.

http://nsgl.gso.uri.edu/vsgcp/vsgcpc00001/1996/1-fish_health_and_welfare.pdf

I think the fear is with something like Bacterial Gill Disease (BGD) where the surviving hatchery fish seem to gain immunity but remain carriers of the bacteria, it would be impossible for the hatcheries not spread the disease when fish are released. The problem is as long as the reservoir exists the diseases can't be eliminated, so the only way to eradicate them is to stop high population density fish raising over a large area, maybe the entire pacific coast of north america, slow or partial closures probably won't work for effective eradication. How would we know if these diseases are killing wild fish? Fish don't die from sickness in the natural environment, they are weakened to the point they become easy prey. A sick fish is an easier meal for a predator, sick fish simply don't come back to spawn and that's what's happening in Puget Sound, and particularly in Puget Sound where fish from many systems must follow similar channels to reach the open ocean. I don't think we know enough about these water born fish pathogens to fully understand their effect, but one must look with great skepticism at the fish hatchery environments and recognize that contained high density populations are always likely breading grounds and reservoirs for disease.

On Mon, Apr 13, 2015 at 11:12 PM, EWSteelheadHatcheries wcr - NOAA Service Account <ewsteelheadhatcheries.wcr@noaa.gov> wrote:

> Thank you for commenting on the early winter steelhead hatcheries pending determination and draft environmental assessment. The comment period for this action will close at 5 p.m. Pacific time on [date of end of comment period].

–
Derek Saam
derek@zahmap.com

EWSteelheadHatcheries wcr - NOAA Service Account <ewsteelheadhatcheries.wcr@noaa.gov> Tue, Apr 14, 2015 at 4:48 PM
To: saamde@gmail.com

Thank you for commenting on the early winter steelhead hatcheries pending determination and draft environmental assessment. The comment period for this action will close at 5 p.m. Pacific time on April 27, 2015.

EWSteelheadHatcheries wcr - NOAA Service Account
<ewsteelheadhatcheries.wcr@noaa.gov>

stop the release of hatchery steelhead

2 messages

Kirk Werner <kirk@itchydogproductions.com> Wed, Apr 15, 2015 at 2:02 PM
To: EWSteelheadHatcheries.wcr@noaa.gov

With regard to the matter of NOAA's NMFS announcement that after 11 years it would withdraw a draft EIS for Puget Sound steelhead hatcheries, I urge you to reconsider this matter.
The release of 290,000 Chambers Creek hatchery steelhead each year into the Nooksack, Stillaguamish and Dungeness rivers will only serve to further threaten the runs of wild steelhead that may still exist in those watersheds. Now is not the time to spend the time, resources and huge monies on bolstering the hatchery program. WDFW should not be in the business of hatcheries. The money and resources wasted on that should be put toward recovery of our native, wild fish.

Sincerely,

Kirk Werner
[redacted]

EWSteelheadHatcheries wcr - NOAA Service Account Wed, Apr 15, 2015 at 2:02 PM
<ewsteelheadhatcheries.wcr@noaa.gov>
To: kirk@itchydogproductions.com

Thank you for commenting on the early winter steelhead hatcheries pending determination and draft environmental assessment. The comment period for this action will close at 5 p.m. Pacific time on April 27, 2015.

EWSteelheadHatcheries wcr - NOAA Service Account
<ewsteelheadhatcheries.wcr@noaa.gov>

Comments on Early Winter Steelhead Hatchery Programs

2 messages

Bill McMillan <monksend@fidalgo.net> Wed, Apr 15, 2015 at 6:06 PM
Reply-To: monksend@fidalgo.net
To: EWSteelheadHatcheries.wcr@noaa.gov

Initial B. McMillan comments

Please find below my comments for WDFW's Early Winter Steelhead Hatchery Programs:

A recent release on March 17th from NOAA indicated that West Coast marine waters from Washington to California have shifted to warmer currents and less productive conditions for species that include marine life histories. It can be anticipated that Puget Sound steelhead will be affected by this.

It was particularly noted in the recent 2013 Skagit River steelhead evaluation report that Chambers Creek origin hatchery steelhead have negative survival rates even lower than wild steelhead during low productivity ocean conditions. This will result in even less contribution to fisheries, and further drain on wild steelhead productivity due to predator attraction of hatchery steelhead smolts related to their domestication and even further negative consequences related to hatchery/wild spawning interactions.

At this point NOAA is playing with fire given the clear notice of a looming ocean productivity decline. Puget Sound steelhead are already listed as Threatened under the Endangered Species Act. The recent decision to shift from an EIS to evaluate the steelhead HGMPs rather than the weaker evaluations required by an EA is inexplicable.

WDFW has been operating their steelhead hatcheries illegally for over 14 years, but now when finally compelled to come into compliance with the Endangered Species Act, WDFW implies it doesn't have time for NOAA to prepare a full environmental impact statement (EIS). Recovery of wild Puget Sound Steelhead is far too important to me to settle for an environmental assessment (EA).

The low bar of an EA requires the least amount of review possible under federal law and does not fulfill the requirements or purposes of NEPA (National Environmental Policy Act). Only through the process of completing a full EIS can NOAA adequately evaluate the cumulative effects of all Puget Sound hatchery programs on threatened and endangered species including Puget Sound's wild steelhead.

Offering the public only 30 days to examine, analyze, and submit comments is unreasonable as the proposal to replace the draft EIS process with a much less rigorous EA transforms the issues dramatically. We urge you to go directly to an EIS or at least add another 30 to 60 days onto the comment period for the EA.

Respectfully,

Bill McMillan
[redacted]

EWSteelheadHatcheries wcr - NOAA Service Account Wed, Apr 15, 2015 at 6:06 PM
<ewsteelheadhatcheries.wcr@noaa.gov>
To: monksend@fidalgo.net

Thank you for commenting on the early winter steelhead hatcheries pending determination and draft environmental assessment. The comment period for this action will close at 5 p.m. Pacific time on April 27, 2015.

EWSteelheadHatcheries wcr - NOAA Service Account
<ewsteelheadhatcheries.wcr@noaa.gov>

Dungeness River Steelhead program

2 messages

Don Johnston <doncj@q.com> Thu, Apr 16, 2015 at 10:49 PM
To: EWSteelheadHatcheries.wcr@noaa.gov

I support getting the Dungeness River steelhead program back on track and re-establishing our early winter hatchery steelhead fishery. Alternative 2 is the plan I support.
Sincerely
Don Johnston
[redacted]

EWSteelheadHatcheries wcr - NOAA Service Account Thu, Apr 16, 2015 at 10:49 PM
<ewsteelheadhatcheries.wcr@noaa.gov>
To: doncj@q.com

Thank you for commenting on the early winter steelhead hatcheries pending determination and draft environmental assessment. The comment period for this action will close at 5 p.m. Pacific time on April 27, 2015.

EWSteelheadHatcheries wcr - NOAA Service Account
<ewsteelheadhatcheries.wcr@noaa.gov>

Comments on Early Winter Steelhead Hatchery Programs.

2 messages

Sherry Anderson <sherryandangus@olypen.com> Fri, Apr 17, 2015 at 8:54 AM
To: EWSteelheadHatcheries.wcr@noaa.gov

I've read the HGMP for propagation of early returning steelhead and favor option #2.
Thanks,
Sherry Anderson
[redacted]

EWSteelheadHatcheries wcr - NOAA Service Account Fri, Apr 17, 2015 at 8:54 AM
<ewsteelheadhatcheries.wcr@noaa.gov>
To: sherryandangus@olypen.com

Thank you for commenting on the early winter steelhead hatcheries pending determination and draft environmental assessment.

EWSteelheadHatcheries wcr - NOAA Service Account
<ewsteelheadhatcheries.wcr@noaa.gov>

Three Hatchery and Genetic Management Plans (HGMPs) for propagation of early-returning ("early") winter steelhead in the Dungeness, Nooksack, and Stillaguamish River watersheds

2 messages

Vic Burri <vicburri@wyoming.com> Fri, Apr 17, 2015 at 9:21 AM
To: EWSteelheadHatcheries.wcr@noaa.gov

Dear NOAA,

I support Alternative 2 as it is supported by both WDFW and the Jamestown S'Klallam tribe.

Vic Burri

[redacted]

EWSteelheadHatcheries wcr - NOAA Service Account Fri, Apr 17, 2015 at 9:21 AM
<ewsteelheadhatcheries.wcr@noaa.gov>
To: vicburri@wyoming.com

Thank you for commenting on the early winter steelhead hatcheries pending determination and draft environmental assessment.

EWSteelheadHatcheries wcr - NOAA Service Account
<ewsteelheadhatcheries.wcr@noaa.gov>

EIS for hatchery evaluation

2 messages

See Attached - 2nd Comment

Doug Hennick <doug.hennick@deckwench.com> Fri, Apr 17, 2015 at 4:01 PM
To: EWSteelheadHatcheries.wcr@noaa.gov
Cc: tim.tynan@noaa.gov, Rob.Jones@noaa.gov

Dear NOAA Fisheries professionals;

The large magnitude of the fish hatchery problem is very evident, and questions about how to regulate hatcheries are so complex that the issues deserve a full EIS looking at the entire set of problems involved with WDFW's early winter steelhead hatchery programs. Certainly citizens deserve more than the 30-days allowed for considering environmental assessments, and I strongly expect that the issues require a more detailed study than can be accomplished during environmental assessments. Please do not allow the process to be degraded by requiring only environmental assessments; this large problem needs an EIS.

Before allowing release of hatchery steelhead I urge you to ensure with fully as much certainty as is possible that we as a society do not damage the survival chances of wild steelhead for millennia to come by catering to sportsmen's desires this decade. We as a culture do not have any right to allow hatchery fish intended for harvest to harm threatened or endangered species. Even if political pressure is intense, and even if hatchery fish support a lot of economic activity, we need to be thinking about protecting the fish genetic resources for the future, not about easy harvest of hatchery fish today.

Doug Hennick

[redacted]

[redacted]

EWSteelheadHatcheries wcr - NOAA Service Account Fri, Apr 17, 2015 at 4:01 PM
<ewsteelheadhatcheries.wcr@noaa.gov>
To: doug.hennick@deckwench.com

Thank you for commenting on the early winter steelhead hatcheries pending determination and draft environmental assessment.

2nd comments

Hennick comments to NOAA

April 30, 2015

Comments by Doug Hennick, for consideration by NOAA, on the Hatchery and Genetic Management Plan (HGMP) for Whitehorse Ponds (Stillaguamish River) Winter Steelhead Hatchery Program (Segregated), by the Washington Department of Fish and Wildlife, July 26, 2014, available at: http://wdfw.wa.gov/hatcheries/hgmp/pdf/puget_sound/whitehorse_early_winter_steelhead__for_re-submission_7_28_2014.pdf

Many or all of these comments may also be pertinent to Kendall Creek, Dungeness River, and other HGMPs.

Although it is not yet fully known what conditions have driven wild steelhead populations to threatened status under the Endangered Species Act, it is possible that releases of hatchery fish into the rivers of Puget Sound is part of, or even most of, the problem. The HGMPs have not disproved that possibility. Some runs of wild salmonids have recovered after hatchery releases were stopped, implying release of hatchery fish was a problem. (Trout in Montana are the best example of this that I know of so far.) Problems caused by hatchery smolt releases may cause large impacts, Puget Sound-wide in geographic scale. This situation deserves a full EIS to determine the overall effect of hatcheries on wild steelhead populations. Reviewing the problem one hatchery at a time seems to be piecemealing a big issue into smaller parts, each of which perhaps could individually slip through the permitting process, but which could cause a large cumulative problem. I request that NOAA evaluate the entire issue of steelhead hatcheries in Puget Sound at one time, with an EIS, rather than following the piecemeal process of approving individual HGMPs sequentially.

That said, I have the following comments about the Whitehorse Ponds proposed HGMP.

Without disproving hatchery impacts, the plan seems to imply that other mechanisms than releases of hatchery smolts must be the problem, saying for example on page 20 "The factors driving the declining abundance of natural origin steelhead... including: 1) the present and increasing threat of destruction, modification and curtailment of natural origin steelhead freshwater, estuarine, and marine habitat; 2) predation and potentially disease, and 3) the inadequate existing regulatory mechanisms to protect natural origin steelhead habitat. " This emphasis on habitat degradation as a primary impact may be wrong because 97% habitat degradation in most watersheds has not happened, but a 97% decline in steelhead populations has apparently happened in some watersheds of Puget Sound. The plan downplays predation and disease caused by hatcheries as problems, and thus assumes the reason for the annihilation is habitat degradation. Thus either habitat degradation causes steelhead population size to diminish in a very non-linear way, or else something other than habitat degradation is driving wild steelhead populations to extinction. The HGMPs should be required to prove that Impacts caused by hatchery smolts are not causing the annihilation. An adequate study to disprove this possibility might be measurement of a wild steelhead juvenile population rearing in a stream segment prior to arrival of a large hatchery smolt release, plus a re-measurement of the wild juvenile population in that segment after the hatchery smolt population has passed through. If hatchery releases are indeed harmless to wild steelhead juveniles, then the wild population should not be changed after the hatchery fish are gone. I am unaware of any study that evaluates the effect of hatchery smolts on wild juvenile populations in this straight-forward manner, and the HGMP does not evaluate it in any other convincing way. Hennick request #1: Before approval, NOAA should require the HGMP to provide straight-forward measurements of the effect of migrating hatchery smolts on wild juveniles, and those measurements should be published in a way that is easily obtainable by the public.

Pg 31. Competition/Niche-Displacement: The plan says "Due to size differences between steelhead smolts and sub-yearlings, competition is probably low with regards to food and spatial preference between species and size. Studies specific to competition or niche displacement in the Stillaguamish River system are not conducted." Wild juvenile steelhead are dependent on aquatic insects and

several of the plan's references document that hatchery smolts do indeed eat aquatic insects (Cannamela, 1993; Pflug et al. ,2013). No reference cited disproves the possibility that hatchery smolts and wild steelhead juveniles try to eat the same thing, and on page 33 Pflug et al., 2013, mentions "...a lack of published data on the comparative feeding habits of hatchery and wild steelhead smolts." On page 29 the HGMP says "Short outmigrating travel times have ... been shown to minimize opportunity for negative interactions (9 days Moore et al. 2013 Puget Sound wide; 16.4 days Goetz et al. 2014, Green River)." However, on page 30 the plan says the volitional release period is approximately one month. Thus even if most individual smolts swim downstream in a week or two, the pulse of smolts in the river apparently can easily cover a month and a half. The plan should not call this a short outmigrating time. If the active growing season is 9-months, this competition would cover 17% of the feeding time available to wild steelhead juveniles. This could be a severe impact to wild juveniles. Each of these issues allow the possibility that the wild population is hurt by competition with hatchery smolts, even if the hatchery smolts are just passing through wild juvenile steelhead habitat. Specific studies of the Stillaguamish are not needed, but the plan should provide specific studies from somewhere showing that hatchery smolts do not cause competition with, or niche displacement of, wild juveniles by eating enough aquatic insects to harm wild steelhead. Apparently such studies do not exist for any river. The plan should not be approved until the assumption is proved that hatchery smolt size, or their relatively short time in the rivers, or anything else, indeed causes their feeding in rivers to have negligible impact on wild steelhead populations.

Hennick request #2: NOAA should not approve a management plan that says "competition is probably low". Before approval, NOAA should require proof that competition is indeed low at all times, and that Table 1.10.2.1 (Performance Indicators addressing risks) be changed to include a performance standard for proving that the release of hatchery smolts causes minimal predation on the food resources which wild steelhead need. Such proof should be published field studies specifically designed to investigate the magnitude of predation by hatchery smolts on the food resources utilized by wild juveniles, or convincing references to specifically pertinent literature that is readily available to the public. A plan saying "probably" [a take does not occur] is not good enough when the threat of extinction exists.

Pg 31. Under *Predation* the plan says: "Steelhead released from hatchery programs are unlikely to prey upon listed species of salmonids ... Based on stomach fullness. " This does not disprove predation impacts if hatchery smolts have instincts to snap at the smaller fish they encounter, even if those smaller fish are too big to swallow. The plan does not consider the possibility that hatchery smolts attack wild juveniles as part of their feeding instincts, and leave the wild fish so injured that they do not survive normally after the unsuccessful attacks. Hennick request # 3: Before approval, NOAA should require that the HGMP evaluate all literature pertinent to the possibility that salmonids sometimes attack other salmonids that are too large to eat, and require the plan to disprove the possibility that this type of behavior may be an impact of hatchery smolts on wild steelhead juveniles in rivers. NOAA should require that Table 1.10.2.1 (Performance Indicators addressing risks) be changed to include the performance indicator "Hatchery smolts do not attack wild juvenile steelhead and leave them wounded by unsuccessful feeding behavior."

EWSteelheadHatcheries wcr - NOAA Service Account
<ewsteelheadhatcheries.wcr@noaa.gov>

2nd comments on steelhead hatchery HGMPs

2 messages

Doug Hennick <doug.hennick@deckwench.com> Thu, Apr 30, 2015 at 1:23 PM
To: EWSteelheadHatcheries.wcr@noaa.gov
Cc: tim.tynan@noaa.gov, Rob.Jones@noaa.gov

Dear NOAA Fisheries professionals;

Please include the attachment as part of my comments on Steelhead HGMPs, specifically the Whitehorse HGMP, but also all the other HGMPs in which the issues discussed might pertain. Please add these to the comments in my email sent to you on April 17, 2015.

Thank you.

Doug Hennick

[redacted]

Hennick comments to NOAA.docx
25K

EWSteelheadHatcheries wcr - NOAA Service Account Thu, Apr 30, 2015 at 1:23 PM
<ewsteelheadhatcheries.wcr@noaa.gov>
To: doug.hennick@deckwench.com

Thank you for commenting on the early winter steelhead hatcheries pending determination and draft environmental assessment. The comment period for this action will close at 5 p.m. Pacific time on May 4, 2015.

EWSteelheadHatcheries wcr - NOAA Service Account
<ewsteelheadhatcheries.wcr@noaa.gov>

Yes to Alternative #2

2 messages

Paul Solie <phs@wavecable.com> Fri, Apr 17, 2015 at 7:07 PM
To: EWSteelheadHatcheries.wcr@noaa.gov

I'm retired now & living within blocks of the Dungeness River. I started fishing for steel head in 1980 on the NF Stilly & now have been looking forward to doing more steelheading on the Dungy. I enjoy the sport of catching hatchery steelhead as much as natives. I would love to see an early winter hatchery program started here & would support it in any & all ways possible. Please make alternative #2 your choice.

Thank You,

Paul Solie

[redacted]

EWSteelheadHatcheries wcr - NOAA Service Account Fri, Apr 17, 2015 at 7:07 PM
<ewsteelheadhatcheries.wcr@noaa.gov>
To: phs@wavecable.com

Thank you for commenting on the early winter steelhead hatcheries pending determination and draft environmental assessment.

EWSteelheadHatcheries wcr - NOAA Service Account
<ewsteelheadhatcheries.wcr@noaa.gov>

Comments on Early Winter Steelhead Hatchery Programs

2 messages

Ken McLeod <libertyacclimated@gmail.com> Wed, Apr 22, 2015 at 3:26 PM
Reply-To: libertyacclimated@gmail.com
To: EWSteelheadHatcheries.wcr@noaa.gov

I respectfully provide the following comments for WDFW's Early Winter Steelhead Hatchery Programs:

WDFW has been stocking early timed winter steelhead for decades to the compliance of what sportsman, and conservationists in Washington state want. The WFC (wild fish conservancy), and their constituents are plaguing our state with lawsuits in attempt to end our hatchery production of fish in what could be described as an eco terrorist like mindset. It is the will of the vast majority of sportsmen within the state of washington that our hatchery programs continue despite what fringe propoganda groups whom draw grant money from our great state, then turn around and sue the very source of that income might encourage.

The WFC does not resemble the will of our states sportsman and conservation groups therein, and their actions serve to siphon money and resources from the state of Washington, and regarding their biased propoganda packets they call "science", the historical and WDFW data clearly contradicts their bias with factual data that overwhelmingly states that early timed winter hatchery fish interaction with "wild" populations is minimal at best, and insignificant.

It is the will of the vast majority that the comment period for the related issues to the winter steelhead hatchery programs and the NOAA permit process not be extended past the original intended timeline.

Respectfully,
Ken George McLeod

Ken McLeod
[redacted]

EWSteelheadHatcheries wcr - NOAA Service Account Wed, Apr 22, 2015 at 3:26 PM
<ewsteelheadhatcheries.wcr@noaa.gov>
To: libertyacclimated@gmail.com

Thank you for commenting on the early winter steelhead hatcheries pending determination and draft environmental assessment.

EWSteelheadHatcheries wcr - NOAA Service Account
<ewsteelheadhatcheries.wcr@noaa.gov>

Early Winter-run Steelhead Hatcheries:

2 messages

Ken j. Mcleod <alpinequest08@yahoo.com> Wed, Apr 22, 2015 at 6:18 PM
Reply-To: "Ken j. Mcleod" <alpinequest08@yahoo.com>
To: "EWSteelheadHatcheries.wcr@noaa.gov" <EWSteelheadHatcheries.wcr@noaa.gov>

PShatcheryEIS.wcr@noaa.gov
NMFS NOAA
West Coast Region
7600 Sand point Way N.E.
Seattle, Wa. 98115
Subj: 2015 Puget Sound Anadromous Hatchery Fish Management Plan/
Public Comment Input
Date: Dec. 1, 2014/Apr.22 2015:
Herein, I submit the following written statements & testimony to the related subject above. I am of firm and resolute endorsement/support of hatchery steelhead & salmon herein all Puget Sound rivers for the overall good of the resource itself, as well as for its vast multitude of users. Therefore, it is essential that the NMFS/NOAA complete the HGMP's for these hatcheries, so that the state can proceed with raising and planting anadromous fish.
Related: Wild winter-run steelhead recovery depends on the use of our hatcheries, primarliy using the same in-river stock, liken to the Wynoochee River system and the past Snider Creek/Sol Duc brood stock hatchery program - "absolutely no interface with the wild gene pool - same genetics!" At the same time, the use of early-timed winter-run Chambers Creek stock planted in other systems is also essential for sportsfishing. These fish do not interface whatsoever with later run (Feb.-May) wild/native steelhead. They arrive at totally different months and are found at different locales, so there is no real significant dilution of genetics.
Further, I also endorse/support the use of Skamania summer-run stock throughout the state for angling enjoyment, these fish are and have been a great recreational resourse, and they DO NOT interface with wild/native summer-runs in the Puget Sound region, i.e. Deer Creek, Canyon Creek, Nfk Tolt, Nfk Skykomish, Upper Green. Those elitists that will have one believe otherwise are entirely incorrect and misleading...their "wild only" agenda basically eliminates the harvest aspect of the resource, in turn they promote no bait fishing, no boat fishing, C&R only, no wild fish harvest, and claims that hatchery fish impede wild fish recovery. Not so! All of the above,in my opinion eliminates most users or the common Joe (majority of license buyers) from really partaking, to include the very old and the young.
Lastly, steelhead & salmon management should rely on sound science, not driven by hysterical emotion, namely "wild zealots" only interested in their own hidden agendas. Remember it's a shared resource for all. I also do not want any further extention on the comment period which would simply delay the process...a ploy by the likes of the Wild Fish Conservancy (WFC) to manouver no release of the winter 2015 smolts into PS streams in early May.
Sincerely,
Ken J. McLeod avid fly fisherman, longtime steelheader, member of Snohomish Sportsmen's Assoc., past pres. (5 terms) Steelhead Trout Club of Wa.

Steve Leider - NOAA Federal <steve.leider@noaa.gov>

Re: Public comment deadline extended for evaluation and assessment of three early winter steelhead hatchery programs in Puget Sound

1 message

Ken j. Mcleod <alpinequest08@yahoo.com> Wed, Apr 22, 2015 at 6:19 PM
Reply-To: "Ken j. Mcleod" <alpinequest08@yahoo.com>
To: Steve Leider - NOAA Federal <steve.leider@noaa.gov>

PShatcheryEIS.wcr@noaa.gov
NMFS NOAA
West Coast Region
7600 Sand point Way N.E.
Seattle, Wa. 98115
Subj: 2015 Puget Sound Anadromous Hatchery Fish Management Plan/
Public Comment Input
Date: Dec. 1, 2014/Apr.22 2015:
Herein, I submit the following written statements & testimony to the related subject above. I am of firm and resolute endorsement/support of hatchery steelhead & salmon herein all Puget Sound rivers for the overall good of the resource itself, as well as for its vast multitude of users. Therefore, it is essential that the NMFS/NOAA complete the HGMP's for these hatcheries, so that the state can proceed with raising and planting anadromous fish.
Related: Wild winter-run steelhead recovery depends on the use of our hatcheries, primarliy using the same in-river stock, liken to the Wynoochee River system and the past Snider Creek/Sol Duc brood stock hatchery program - "absolutely no interface with the wild gene pool - same genetics!" At the same time, the use of early-timed winter-run Chambers Creek stock planted in other systems is also essential for sportsfishing. These fish do not interface whatsoever with later run (Feb.-May) wild/native steelhead. They arrive at totally different months and are found at different locales, so there is no real significant dilution of genetics.
Further, I also endorse/support the use of Skamania summer-run stock throughout the state for angling enjoyment, these fish are and have been a great recreational resourse, and they DO NOT interface with wild/native summer-runs in the Puget Sound region, i.e. Deer Creek, Canyon Creek, Nfk Tolt, Nfk Skykomish, Upper Green. Those elitists that will have one believe otherwise are entirely incorrect and misleading...their "wild only" agenda basically eliminates the harvest aspect of the resource, in turn they promote no bait fishing, no boat fishing, C&R only, no wild fish harvest, and claims that hatchery fish impede wild fish recovery. Not so! All of the above,in my opinion eliminates most users or the common Joe (majority of license buyers) from really partaking, to include the very old and the young.
Lastly, steelhead & salmon management should rely on sound science, not driven by hysterical emotion, namely "wild zealots" only interested in their own hidden agendas. Remember it's a shared resource for all. I also do not want any further extention on the comment period which would simply delay the process...a ploy by the likes of the Wild Fish Conservancy (WFC) to manouver no release of the winter 2015 smolts into PS streams in early May.
Sincerely,
Ken J. McLeod avid fly fisherman, longtime steelheader, member of Snohomish Sportsmen's Assoc., past pres. (5 terms) Steelhead Trout Club of Wa.

On Thursday, April 16, 2015 11:24 AM, Steve Leider - NOAA Federal <steve.leider@noaa.gov> wrote:

You are receiving this email because of your interest in salmon and steelhead hatcheries in Puget Sound.

On March 26, 2015, NOAA Fisheries announced the availability for public review of a pending determination of three Hatchery and Genetic Management Plans (HGMPs) for propagation of early-returning ("early") winter steelhead in the Dungeness, Nooksack, and Stillaguamish River watersheds in Puget Sound. The availability of a draft environmental assessment (EA), evaluating the anticipated effects of NOAA Fisheries' pending determination on those HGMPs pursuant to the National Environmental Policy Act (NEPA) was included in the announcement. The announcement opened a 30-day public comment period. Due to an issue with the e-mail address provided for receipt of comments (EWSteelheadHatcheries.wcr@noaa.gov), any comments submitted to that email address prior to April 14, 2015, were not received. Therefore, NOAA Fisheries is publishing a new Federal Register notice to request that any such comments be re-submitted. NOAA Fisheries will extend the comment period to May 4, 2015, to facilitate any re-submittals of comments to that email address.

The pending determination and environmental assessment documents for the three early winter steelhead hatchery programs now open for public review and comment are available on the West Coast Region website at http://www.westcoast.fisheries.noaa.gov/hatcheries/hgmp/ew_steelhead_proposed_eval_draft_ea.html

Please note that the draft EA for these three early winter steelhead programs is not replacing the recently withdrawn Puget Sound Hatcheries draft EIS. That draft EIS was initiated in 2004 when the hatchery co-managers (WDFW and Puget Sound Indian Tribes) submitted to NOAA Fisheries two joint Resource Management Plans (RMPs) for all hatchery programs in Puget Sound. Earlier this year, the co-managers withdrew their 2004 RMPs and associated HGMPs, and NOAA Fisheries responded by withdrawing the draft EIS. The hatchery co-managers are replacing those plans generally with watershed-specific HGMPs, and as those are received, NOAA Fisheries will determine whether NEPA requires us to prepare an EA or EIS. For the three early winter steelhead programs subject to your request, NOAA Fisheries has published a draft EA for public review to determine the appropriate level of NEPA review. If the three programs are not likely to cause significant impacts to the human environment, the EA will be finalized, and if yes, NOAA Fisheries will prepare a draft EIS. New NEPA analyses (including EISs or EAs) will continue to be initiated as NOAA Fisheries receives new HGMPs from the co-managers. Regardless of how hatchery programs are bundled together for review, NOAA Fisheries will meet the requirements of NEPA and the ESA.

Information on the withdrawal of the Puget Sound Hatcheries draft EIS is available on the website at
http://www.westcoast.fisheries.noaa.gov/hatcheries/ps_deis/ps_deis.html

EWSteelheadHatcheries wcr - NOAA Service Account
<ewsteelheadhatcheries.wcr@noaa.gov>

Dungeness River steelhead program

2 messages

Ron Hayes <ron@redfernconsultants.com> Mon, Apr 27, 2015 at 10:24 AM
To: EWSteelheadHatcheries.wcr@noaa.gov
Cc: johnsjerry@gmail.com, Dave Croonquist <dcroonquist@gmail.com>

I am a recreational fisherman and currently a member of the East Jefferson Chapter of Puget Sound Anglers. We support getting the Dungeness River steelhead program back on track and re-establishing our early winter hatchery steelhead fishery. Alternative 2 is the plan of choice and is supported by our 70 member organization.

Thank you,

Ron Hayes

[redacted]

EWSteelheadHatcheries wcr - NOAA Service Account Mon, Apr 27, 2015 at 10:24 AM
<ewsteelheadhatcheries.wcr@noaa.gov>
To: ron@redfernconsultants.com

Thank you for commenting on the early winter steelhead hatcheries pending determination and draft environmental assessment. The comment period for this action will close at 5 p.m. Pacific time on May 4, 2015.

EWSteelheadHatcheries wcr - NOAA Service Account
<ewsteelheadhatcheries.wcr@noaa.gov>

Comments on Early Winter Steelhead Hatchery Programs

2 messages

Rory O'Connor <rory@thewhiteroom.com> Mon, Apr 27, 2015 at 2:09 PM
To: EWSteelheadHatcheries.wcr@noaa.gov

I am writing in support of the approval of HGMPs for North Sound rivers. Winter steelhead represent an important fishery both from a sportfishing opportunity standpoint, and also an economic standpoint. I hope you can speed along the approval of the HGMPs so smolts can be released.

Thanks,
Rory O'Connor
[redacted]

EWSteelheadHatcheries wcr - NOAA Service Account Mon, Apr 27, 2015 at 2:10 PM
<ewsteelheadhatcheries.wcr@noaa.gov>
To: rory@thewhiteroom.com

Thank you for commenting on the early winter steelhead hatcheries pending determination and draft environmental assessment. The comment period for this action will close at 5 p.m. Pacific time on May 4, 2015.

EWSteelheadHatcheries wcr - NOAA Service Account
<ewsteelheadhatcheries.wcr@noaa.gov>

Comments on Winter Steelhead Hatchery Program

2 messages

CRAIG KING <ninahc@hotmail.com> Mon, Apr 27, 2015 at 8:20 PM
Reply-To: ninahc@hotmail.com
To: EWSteelheadHatcheries.wcr@noaa.gov

Dear Mr. Tim Tynan and Mr. Rob Jones,

I think that NOAA should continue the hatchery program. From what I have read it is having positive effects on wild populations. I don't want to see public outcry based on misleading information force the hand of public policy. Let the science speak for itself.

http://onlinelibrary.wiley.com/doi/10.1111/mec.12046/pdf — Hess et al. 2012. Supportive breeding. Mole. Ecol

Results suggest that supplementation following similar management practices (e.g. 100% local, wild-origin brood stock) can successfully boost population size with minimal impacts on the fitness of salmon in the wild.

CRAIG KING
[redacted]

EWSteelheadHatcheries wcr - NOAA Service Account Mon, Apr 27, 2015 at 8:20 PM
<ewsteelheadhatcheries.wcr@noaa.gov>
To: ninahc@hotmail.com

Thank you for commenting on the early winter steelhead hatcheries pending determination and draft environmental assessment. The comment period for this action will close at 5 p.m. Pacific time on May 4, 2015.

EWSteelheadHatcheries wcr - NOAA Service Account
<ewsteelheadhatcheries.wcr@noaa.gov>

Comments on Early Winter Steelhead Hatchery Programs

2 messages

Richard Burkhalter <dburkhalterd@comcast.net> Tue, Apr 28, 2015 at 1:20 PM
Reply-To: dburkhalterd@comcast.net
To: EWSteelheadHatcheries.wcr@noaa.gov

By not propagation hatchery steelhead there will be know steelhead to fish for now or into the future .
A better way to increase the wild fish population is to take the Eggs from hatchery fish , planted them in the head water of these streams and let these fish migrate out as wild fish. In this manner you will get a return of fish that have to fight in the wild for their survival . Thus they have to compete in the natural environment . With any luck in twenty years you may have a health population of wild fish . Under the present proposal I don't expect a health population for the next 100 to 200 years, if that. I grew up in South West Washington on dairy farm on the Willapa River and fished for all the different species of fish. To give you an Idea on the decline of wild fish I observed the following ;In the 1940'and early 50's I could count 6 to 12 pairs of Fall Chinook spawning in each of the riffles . Five years ago I was fishing for silvers in the same area . Two biologist floated down the river counting Fall Chinook Redds . From where they put in to where we were fishing approximately 5 miles of river they counted 4 fall Chinook redds .What a shame.
We have over fished the resource to extension. It not pollution that caused the problem .
I have a masters in Sanitary Engineering and worked for The International Pacific Salmon Fisheries Commission for two years and Than 25 YEARS WITH water pollution control commission /Ecology department REGULATING THE major industries IN THE STATE .pUPL pAPER, oIL refineries AND aluminum plants . I INTRODUCTED THE FISH BIOASSY IN THE REGULATORY WASTE WATER PERMIT IN THE 70'S which REQUIRED MAJOR CLEAN UP BY THESE INDUSTRIES .The reduction in pollution was over 90%.

for THE PAST TWO YEARS I HAVE discontinue fishing for Steelhead in Washington because of the poor opportunity in catching one . Prior to that I have released all the steelhead I caught in these small streams for the past 10 years.
I now fish for steelhead in Alaska for the past 20 years . Situk River Yakutat AK. WHICH IS A CATCH AND RELEASE RIVER . I AVERAGE ABOUT 10 STEELHEAD Released per DAY .
I am now retired after 20 plus years as a consultant . I am 75.

thank YOU FOR LETTING ME EXPRESS MY VIEWS

Richard Burkhalter PE, MS sanitary engineering / Environmental Engr.

Richard Burkhalter
[redacted]

EWSteelheadHatcheries wcr - NOAA Service Account Tue, Apr 28, 2015 at 1:21 PM
<ewsteelheadhatcheries.wcr@noaa.gov>
To: dburkhalterd@comcast.net

Thank you for commenting on the early winter steelhead hatcheries pending determination and draft environmental assessment. The comment period for this action will close at 5 p.m. Pacific time on May 4, 2015.

EWSteelheadHatcheries wcr - NOAA Service Account
<ewsteelheadhatcheries.wcr@noaa.gov>

Comments on Early Winter Steelhead Hatchery Programs

2 messages

LewisBoyd@aol.com <LewisBoyd@aol.com> Wed, Apr 29, 2015 at 3:36 PM
To: EWSteelheadHatcheries.wcr@noaa.gov

NOAA personel,

It has been a year since the lawsuit between WFC and WDFW. There was a moratorium of other lawsuits being file by WFC or any other entity against WDFW for several years. The three rivers are a start, but at this rate, other lawsuits will be coming forth before all hatcheries are permitted.

Without hatcheries there would not be much fishing around PS or other parts of WA state.

I'd say keep up the good work but you are so far behind it appears you to be in first place being lapped by other HGMP's.

Lewis

EWSteelheadHatcheries wcr - NOAA Service Account Wed, Apr 29, 2015 at 3:36 PM
<ewsteelheadhatcheries.wcr@noaa.gov>
To: LewisBoyd@aol.com

Thank you for commenting on the early winter steelhead hatcheries pending determination and draft environmental assessment. The comment period for this action will close at 5 p.m. Pacific time on May 4, 2015.

EWSteelheadHatcheries wcr - NOAA Service Account
<ewsteelheadhatcheries.wcr@noaa.gov>

Comments for Puget Sound Early Winter Steelhead Hatchery Programs

1 message

Brice Crayne <brice.crayne@gmail.com> Mon, May 4, 2015 at 10:46 AM
Reply-To: brice.crayne@gmail.com
To: EWSteelheadHatcheries.wcr@noaa.gov

Hello Tim Tynan and Rob Jones,

As you are aware, wild steelhead are struggling to survive the ever-increasing demand and pressures from human causes. Without a proper Environmental Impact Assessment in the Puget Sound, it is unlikely that future generations will be able to experience the Puget Sound recreational steelhead fishery; and without this fishery current steelhead fisherman and women will be forced to put additional pressure on the Olympic, Lower Columbia, and upper Columbia stocks which are slowly recovering due to your recent actions. Without this environmental assessment the Puget Sound steelhead will likely perish.
Please take action to protect these fish and those of the rest of WA state.

Brice Crayne

Brice Crayne
[redacted]

Steve Leider - NOAA Federal <steve.leider@noaa.gov>

Comments for Puget Sound Early Winter Steelhead Hatchery Programs

1 message

Walter Stoeckmann <Walter@hfdw.com> Mon, May 4, 2015 at 11:55 AM
To: EWSteelheadHatcheries.wcr@noaa.gov, steve.leider@noaa.gov

Dear Mr. Leider and the NMFS Sustainable Fisheries Program,

I am writing in response to NOAA's recent decision to withdraw the Puget Sound Draft Environmental Impact Statement, and instead move forward with an Environmental Assessment of WDFW and Puget Sound Treaty Tribes' (Co-Managers) Hatchery Genetic Management Plans that will release Chambers Stock hatchery Steelhead into the Nooksack, Stillaguamish, and Dungeness Rivers.

The Puget Sound DPS is currently listed as threatened under the Endangered Species Act, and NOAA cited hatchery stock releases among the factors that contributed to the threatened status of the DPS. I am concerned that at close to 3% of historical abundance, the Puget Sound Steelhead DPS will not be able to recover without a rigorous scientific review and full consideration of alternatives to Puget Sound hatchery programs. An Environmental Impact Statement (EIS) is the necessary method to scientifically evaluate the genetic and ecological risks to wild populations from these hatchery programs, and to consider the full range of reasonable alternatives for helping minimize the genetic impacts to the threatened Puget Sound Steelhead DPS. I am concerned that an Environmental Assessment lacks the scientific rigor of an EIS and that it is inadequate for protecting threatened populations because it contains unverified assumptions and incomplete scientific evaluation of all of the impacts.

Given what is at stake for recovery of Puget Sound Steelhead, as well as the ESA-listed Puget Sound Chinook salmon and Hood Canal summer chum salmon, I request that you conduct an Environmental Impact Statement for the hatchery programs submitted by the co-managers for Chambers Creek stock hatchery Steelhead releases into the Nooksack, Stillaguamish, and Dungeness Rivers. Additionally, I also request a 60-day extension on the original public comment period in order for the public to fully participate in this important federal decision affecting threatened wild steelhead in Puget Sound.

Respectfully,

Sincerely,
Walter Stoeckmann
[redacted]

EWSteelheadHatcheries wcr - NOAA Service Account
<ewsteelheadhatcheries.wcr@noaa.gov>

Comments on Early Winter Steelhead Hatchery Programs

2 messages

Fred Teixeira <teixeira@gowebway.com> Wed, Apr 15, 2015 at 1:00 PM
Reply-To: teixeira@gowebway.com
To: EWSteelheadHatcheries.wcr@noaa.gov

I respectfully provide the following comments for WDFW's Early Winter Steelhead Hatchery Programs:

WDFW has been operating their steelhead hatcheries illegally for over 14 years, but now when finally compelled to come into compliance with the Endangered Species Act, WDFW implies it doesn't have time for NOAA to prepare a full environmental impact statement (EIS). Recovery of wild Puget Sound Steelhead is far too important to me to settle for an environmental assessment (EA).

The low bar of an EA requires the least amount of review possible under federal law and does not fulfill the requirements or purposes of NEPA (National Environmental Policy Act). Only through the process of completing a full EIS can NOAA adequately evaluate the cumulative effects of all Puget Sound hatchery programs on threatened and endangered species including Puget Sound's wild steelhead.

Offering the public only 30 days to examine, analyze, and submit comments is unreasonable as the proposal to replace the draft EIS process with a much less rigorous EA transforms the issues dramatically. We urge you to go directly to an EIS or at least add another 30 to 60 days onto the comment period for the EA.

Respectfully,

Fred Teixeira
[redacted]
Redmond, WA 98052

EWSteelheadHatcheries wcr - NOAA Service Account Wed, Apr 15, 2015 at 1:00 PM
<ewsteelheadhatcheries.wcr@noaa.gov>
To: teixeira@gowebway.com

Thank you for commenting on the early winter steelhead hatcheries pending determination and draft environmental assessment. The comment period for this action will close at 5 p.m. Pacific time on April 27, 2015.

Example - via WFC form

EWSteelheadHatcheries wcr - NOAA Service Account
<ewsteelheadhatcheries.wcr@noaa.gov>

Comments for Puget Sound Early Winter Steelhead Hatchery Programs

2 messages

Matthew Lund <matthew.lund0@gmail.com> Thu, Apr 23, 2015 at 4:17 PM
To: EWSteelheadHatcheries.wcr@noaa.gov, steve.leider@noaa.gov

Dear Mr. Leider and the NMFS Sustainable Fisheries Program,

I am writing in response to NOAA's recent decision to withdraw the Puget Sound Draft Environmental Impact Statement, and instead move forward with an Environmental Assessment of WDFW and Puget Sound Treaty Tribes' (Co-Managers) Hatchery Genetic Management Plans that will release Chambers Stock hatchery Steelhead into the Nooksack, Stillaguamish, and Dungeness Rivers.

The Puget Sound DPS is currently listed as threatened under the Endangered Species Act, and NOAA cited hatchery stock releases among the factors that contributed to the threatened status of the DPS. I am concerned that at close to 3% of historical abundance, the Puget Sound Steelhead DPS will not be able to recover without a rigorous scientific review and full consideration of alternatives to Puget Sound hatchery programs. An Environmental Impact Statement (EIS) is the necessary method to scientifically evaluate the genetic and ecological risks to wild populations from these hatchery programs, and to consider the full range of reasonable alternatives for helping minimize the genetic impacts to the threatened Puget Sound Steelhead DPS. I am concerned that an Environmental Assessment lacks the scientific rigor of an EIS and that it is inadequate for protecting threatened populations because it contains unverified assumptions and incomplete scientific evaluation of all of the impacts.

Given what is at stake for recovery of Puget Sound Steelhead, as well as the ESA-listed Puget Sound Chinook salmon and Hood Canal summer chum salmon, I request that you conduct an Environmental Impact Statement for the hatchery programs submitted by the co-managers for Chambers Creek stock hatchery Steelhead releases into the Nooksack, Stillaguamish, and Dungeness Rivers. Additionally, I also request a 60-day extension on the original public comment period in order for the public to fully participate in this important federal decision affecting threatened wild steelhead in Puget Sound.

Respectfully,

Example-via NFS form

Sincerely,
Matthew Lund
[redacted]

EWSteelheadHatcheries wcr - NOAA Service Account Thu, Apr 23, 2015 at 4:17 PM
<ewsteelheadhatcheries.wcr@noaa.gov>
To: bounces+1639030-ff71-ewsteelheadhatcheries.wcr=noaa.gov@sendgrid.me

Thank you for commenting on the early winter steelhead hatcheries pending determination and draft environmental assessment.

EWSteelheadHatcheries wcr - NOAA Service Account
<ewsteelheadhatcheries.wcr@noaa.gov>

Comments on Winter Steelhead Hatchery Program

2 messages

Patrick M. Donovan <patrickmdonovan@gmail.com> Mon, Apr 27, 2015 at 10:52 AM
Reply-To: patrickmdonovan@gmail.com
To: EWSteelheadHatcheries.wcr@noaa.gov

Dear Mr. Tim Tynan and Mr. Rob Jones,

I'm writing to encourage you to conduct a full review of Washington's winter steelhead hatcheries in an environmental impact statement. The potential harms from the state's hatcheries on wild steelhead are simply too great – and a cursory environmental assessment won't cut it. As documented by your own scientists, hatcheries cause serious problems for wild fish and are a major impediment to steelhead recovery. And so ultimately we must phase out our reliance on hatcheries as a way to replace these beautiful, wild fish.

I am also concerned that the public was allowed only 30 days to examine this issue and submit comments on the environmental assessment. And so I urge you to scrap the assessment, develop a full environmental impact statement, and open a new comment period to make sure we're doing what's best for threatened steelhead.

Sincerely,

Patrick M. Donovan
[redacted]

EWSteelheadHatcheries wcr - NOAA Service Account Mon, Apr 27, 2015 at 10:52 AM
<ewsteelheadhatcheries.wcr@noaa.gov>
To: patrickmdonovan@gmail.com

Thank you for commenting on the early winter steelhead hatcheries pending determination and draft environmental assessment. The comment period for this action will close at 5 p.m. Pacific time on May 4, 2015.

Example - Via Center for Biological Diversity form